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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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Civil Service Commission.

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ASSISTANT EXAMINERS IN THE PATENT OFFICE (20-30), 4th March.

The date specified is the latest at which applications can be received. They must be made on forms to be obtained, with particulars, from the SECRETARY, Civil Service Commission, Burlington Gardens, London, W. 1. C 668

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SESSION 1919-20.

LENT TERM BEGINS 8th JANUARY, 1920.

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Applications to Tender must be received on or before the 30th inst., and must be accompanied by full particulars of the firm's experience in beet sugar factory work, and the time required in which to prepare and lodge the complete scheme, drawings and tender. D 86

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Offers, under cover, marked "Hot Water Heaters, &c.," should reach me not later than Monday, the 9th February, proximo.

By Order,
W. HARDING ROBERTS,
Clerk.

40, Clarence Street, Southend-on-Sea,
20th January, 1920. D 69

AUCKLAND HARBOUR BOARD, NEW ZEALAND.

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C. WILLIAM TAGG, Town Clerk. D 59

INTERNATIONAL COMPETITION.

Aalborg Town Council's

COMMITTEE of King Chr. IX Pontoon Bridge HEREBY INVITE DESIGNS for a New BRIDGE CONNECTION ACROSS THE LIMFJORD, BETWEEN AALBORG AND NORRESUNDBY (DENMARK).

Three Prizes are offered, viz.:—

1st Prize	...	...	Kroner 10,000.00
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The Committee furthermore reserve the right to purchase some plans which have received no prize, at a sum of Kroner 2000.00 each.

The plans are to be submitted before September 30th, 1920.

Program with descriptions, maps, etc., will be furnished in the Danish, English, German, or French language, on application to the HARBOUR ENGINEER'S OFFICE, Nyhavnsgade 12, Aalborg, Denmark, against a deposit of Kroner 50.00, which amount will be refunded to those who submit plans in due time, or return the documents furnished in undamaged condition before the expiration of the time stipulated for the competition.

THE COMMITTEE OF KING CHR. IX PONTOON BRIDGE,
Aalborg,
January 1st, 1920. C 902

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R. R. LINTHORNE, Town Clerk.
21st January 1920. D 96

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COVENTRY EDUCATION COMMITTEE.

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FREDK. HORNER, Secretary.
Education Dept., Council House, Coventry,
17th January 1920. D 50

KENT EDUCATION COMMITTEE.

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H. SALTER DAVIES, Director of Education.
17th January, 1920. D 34

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Commencing salary £430.

Further particulars can be obtained from the PRINCIPAL. Applications must be made on forms supplied by the undersigned, and returned to him not later than Thursday, January 29th.

J. M. WYNNE, Director of Education.
Education Offices, Dudley. C 899

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UNIVERSITY OF BIRMINGHAM.

CIVIL ENGINEERING DEPARTMENT.

Professor F. C. LEA, D.Sc., M.Inst.C.E.

Applications are Invited for

the POST of LECTURER in the Civil Engineering Department to succeed Mr. W. N. Thomas, M.Sc., A.M.Inst.C.E., who has been appointed Assistant to the Professor of Engineering in the University of Oxford.

Stipend £350 per annum.

Applications, with testimonials and references, should be forwarded to the undersigned not later than Monday, the 23rd of February, 1920.

Further particulars may be obtained from GEO. H. MORLEY, Secretary. D 102

H.M. DOCKYARD SCHOOLS.

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FLUID MOTION AND VISCOSITY.

The Effect upon Fluid Motion of local Heating due to Viscosity and the Comparison between Experiments carried out in Fluids in the Two Different States—Liquid and Gaseous.

By W. L. COWLEY, A.R.C.Sc., D.I.C., Wh.Sch., Scientific Assistant at the National Physical Laboratory, Teddington.

IT is usual when studying the flow of fluids past bodies, especially when treating the subject from the point of view of the dimensional theory, to suppose that the force upon the body depends only upon the properties of the fluid ρ, ν and V, the density, kinematic viscosity and the velocity of sound respectively; and also upon v the velocity, supposed constant, of the general mass of the medium relative to the body, and l the linear scale of the system referred to some drawing. Hence by the dimensional theory it is shown that the interacting force is given by:

$$R = \rho\, l^2\, v^2 f_1 (v\, l/\nu, v/V) \quad . \quad . \quad . \quad (1)$$

where the form of the function f_1 depends upon the shape and also, unless (1) be regarded as a vector equation, upon the orientation of the body to the general flow.

The term v V is present in virtue of the compressibility of the fluid and represents to a large extent the part played by wave motion or sound. When the velocities and consequently the pressure variations in the medium are small, the energy dissipated in wave formation becomes negligible, and for this reason equation (1) is often written in the more convenient form:

$$R = \rho\, l^2\, v^2 f_2 (v\, l/\nu) \quad . \quad . \quad . \quad (2)$$

f_2 being the form f_1 assumes when v V is made zero.

These equations indicate that experiments carried out in two distinctly different fluids, even if one is a liquid and the other a gas, are directly comparable. By arranging v and l so that $v\, l/\nu$ is the same in each case, the resistances become proportional to the product $\rho\, v^2\, l^2$ if the compressibility is small, and the fact that the fluids exist in two different states does not appear to affect the problem in the slightest degree. Whether or not this is the case remains for experiment to verify, and to this end a number of tests have been carried through both of a qualitative and quantitative nature. The flow of air and of water when made visible by smoke or small particles shows a remarkable agreement in the two cases at corresponding values of $v\, l/\nu$. This seems a remarkable tribute to equation (2), but when a more exact test is made, as for example, if the resistance of a strut is found first when towed through water and, secondly, when in a current of air in a wind channel, the results obtained are such that even competent authorities on the subject have been led to doubt the above two equations. This discrepancy might be due to two causes: the turbulent nature of the flow in the wind channel and the possible presence and importance of other factors as yet neglected.

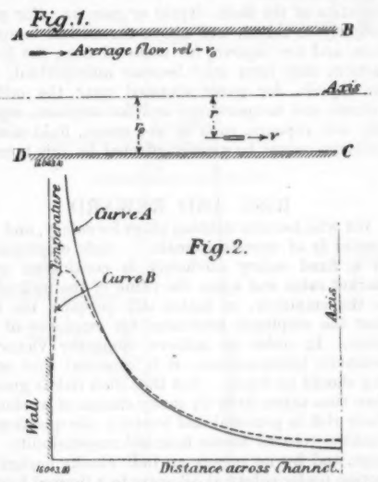
The first is undoubtedly a serious question in as far as it affects the whole foundation of wind-channel research, but as yet there has been little, if any, evidence to support it. On the other hand, however, our original suspicions that the question of the state of the fluid may have some important bearing upon the question appear to receive weight, and probably one or even more factors yet remain to be considered. It is proposed, therefore, in the present article to examine whether the three physical constants enumerated above fully define the fluid for hydrodynamical purposes and to establish as far as possible the most general form for the resistance.

The property defining the state presents a little difficulty at this stage, but it might clear the ground initially if we discussed the effects, direct and indirect, of temperature upon fluid motion. The effect of heat has been supposed in the past to modify the flow only in as far as an increase in temperature affects ρ, ν and V for the general mass of the fluid. This assumption would be quite justifiable if the temperature were constant throughout, but it will be seen that this is not the case.

Consider by way of illustration the two dimensional motions of a viscous fluid between two parallel walls A B and C D, the flow being from A B to C D. For steady lamina flow, neglecting compressibility and supposing ν constant throughout, the velocity of the fluid varies across the channel according to a parabolic law, being zero at the boundaries and maximum along the axis. Thus if r is the distance from the axis, the velocity v is given by:

$$\frac{r^2}{r_0^2} = \frac{2}{3}\left(\frac{3}{2} - \frac{v}{v_0}\right) \quad . \quad . \quad . \quad (3)$$

where $2\,r_0$ is the width of the channel and v_0 the average velocity of the fluid. Although the motion is steady the pressure will gradually drop from one end of the channel to the other in the direction of the flow owing to the dragging action of the fluid upon the walls, and the energy required to overcome this and maintain the motion eventually becomes dissipated into heat. The mechanism within the fluid causing this is somewhat complicated. The fluid to some extent may be considered in a state of sheer, but whereas it requires no energy to maintain a sheer in a solid once established, such is not the case in a fluid. In fact the rate at which



energy is being dissipated into heat is proportional to the rate of change of sheer across the channel, Thus the loss of energy per second per unit volume is:

$$-2\,\rho\,\nu\frac{d^2 v}{d\,r^2} = 6\,\rho\,\nu\frac{v_0}{r_0^2} \quad . \quad . \quad . \quad (4)$$

If K be the specific heat of the fluid and if conduction be neglected the rate of increase of temperature with time will be:

$$\frac{d\,\Theta}{d\,t} = \frac{6\,\rho\,\nu\,v_0}{K\,J\,r_0^2} \quad . \quad . \quad . \quad . \quad (5)$$

where J is Joule's equivalent. Suppose that the fluid starts from B C with a uniform temperature Θ across the channel. An element situated at a distance r from the axis will move parallel to the walls with a velocity v and increase in temperature at a rate given by (5). The time taken for the fluid distance r from the axis to travel from B C to A D a distance L will be L v, so that the gain in temperature will amount to:

$$6\,\frac{\rho\,\nu}{K\,J}\cdot\frac{v_0}{r_0^2}\cdot\frac{l}{v}$$

and reaches, at A D, a temperature:

$$\theta\,\theta_0 + \frac{4\,\rho\,\nu\,l}{K\,J}\cdot\frac{1}{r_0^2 - r^2} \quad . \quad . \quad (6)$$

This curve is plotted in general form in Fig. 2 (curve A). Near the walls the curve tends to infinity, but if conductivity had been taken into account the temperature variation would have been modified to the form given in curve B.

The temperature rapidly increases as we proceed inwards from the walls, when it reaches a high maximum in the case of a gas owing to the small values of K and of the conductivity, at a short distance inside. It then falls off at not quite so rapid a rate until the main body of the fluid is reached. Here the fluid is but slightly heated in comparison.

This increase in temperature is accompanied by a change in viscosity. For air ν increases at a slightly greater rate than 1 per cent. per degree Centigrade rise, while on the other hand it decreases for water at the rate of 4 per cent. The result of this upon the flow might under certain conditions be considerable, for it is in the neighbourhood of the walls that eddies originate when the flow becomes turbulent. Since on the one hand the fluid is rendered more viscous by the local heating, and on the other less, this critical part of the channel would be affected in a totally different manner in each case, resulting in considerable modification in the flow. A similar state of affairs would occur in any other fluid-motion problem. The most active portion in producing turbulence, usually in the neighbourhood of the body where the rate of shear is large and the velocity small, or in the region of quasi-discontinuities in flow, is the part that receives the greatest rise in temperature. This rise taking place as it does in the most sensitive part of the fluid will consequently have a comparatively large effect upon the general flow, and local heating must accordingly find a place in equation (1). For this reason it must be supposed that R depends upon Q, say the rate of change of viscosity with temperature, and K the specific heat of the fluid at constant pressure, as well as upon the other quantities previously mentioned.

So far, the state of the fluid has not entered into our investigation. To introduce this, we must take a more general survey of the whole subject. It is clear that there would be no point in gathering together all the physical properties of the fluid, and supposing that the motion depended upon the whole collection. If such were done, the function f would be found to contain a large number of variables, but no evidence would be present to show whether these variables could not all be expressed in terms of three others, $v\, l/\nu$, v/V, and the term due to local heating. The conductivity of a gas, for example, is the product $\rho\,\nu\,K_v$ where K_v is the specific heat at constant volume, and, therefore, would be superfluous if these three constants had already found place in our collection. In order that no doubt may be thrown upon necessity for the inclusion of any one factor, it would be advisable to get to the very root of the matter by considering the least number of terms that could be used to define the fluid completely from the hydrodynamical standpoint. For the reason we could resort to the kinematic theory of gases.

A gas or any fluid, according to this conception, is composed of a large number of very small particles or molecules, each having identically the same properties, if the fluid be a single chemical compound. At a particular instant, each molecule will possess, owing to its motion and vibration, a certain amount of energy which will not be the same, however, for all the molecules. The motion of the fluid at any point will be the average motion of a large number of molecules in the neighbourhood of that point, and the density there will depend upon the density of packing. The probable energy of any molecule relative to the fluid in its immediate vicinity will follow definite laws which will depend upon the properties of the molecules, and this density of packing. From this simple conception we can define the fluid completely, as far as its motion is concerned by the constants—

- m = mass of each molecule.
- s = size or its equivalent of the molecule expressed, say, as a volume.
- n = a number which represents the ratio between the energy of a molecule to the amount of kinematic energy it possesses due to its translational motion.
- N = number of molecules per unit volume.
- u = most probable velocity of the molecule.

All the physical constants of the fluid can be represented as functions of these quantities as variables. Some of these terms are small and others large, but all are required if we wish to treat the problem generally, and although it might be thought that such a small term as s might be ignored, yet this very term plays an important part in certain phenomena, and it is conceivable that it would have a definite influence upon fluid motion. Whether this is so or not must be left to experimental verification for the particular case requiring treatment.

The importance of s is clearly evident in Van der

Waal's equation, which represents very well the relation between temperature, pressure and volume of an actual fluid. If p be the pressure of the gas and S its volume, this equation is of the form

$$\left(p + \frac{a}{S^2}\right)\left(S - b\right) = R\,\theta \quad . \quad . \quad (7)$$

where a, b and R are constants and Θ temperature. The constant b depends upon s, and although small, plays a very important part when S becomes small, that is, when the fluid is in the liquid state or a highly-compressed gas. If the gas be perfect, *i.e.*, obeys Boyle's law, a and b must be put equal to zero in (7), and the isothermals or the curves giving the relation between p and S when Θ is made constant, will be identical for the two cases, when S is large (Fig. 3).

The term b depends directly upon the volume of the molecules, and, therefore, upon s, and if neglected would give absurd results. If neglected together with a Boyle's equation would be obtained, which we know does not hold when the fluid is becoming liquified, and if neglected alone, while a is given a definite value, the pressure of the fluid would become negative for small values of S (Fig. 3). We can only infer, therefore, that s plays an important part, both at high compressions in a gas and when the fluid changes its state, and there is no reason to doubt that it also plays an important part in fluid motion problems. It certainly shows its presence in the slope of the isothermal curve for a liquid, and hence in the elasticity, and, therefore, we may say that the term v/V in equation (1) is greatly modified by the magnitude of s.

It would be a fallacy to suppose that variations in s are taken up by making corresponding changes in V, or even in ν, if necessary, as will be here seen. Using the quantities defining the fluid from the molecular conception of matter we obtain by means of the dimensional theory, the resisting force

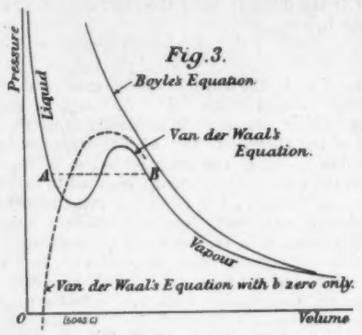
$$R = m\,N \cdot v^2\,l^2\,f_3\left\{s \cdot N, n, N\,l^3, \frac{u}{v}\right\} \quad . \quad (8)$$

The function f_3 contains four variables, and it is impossible by any combination of these to reduce the equation into the form given by (1). Equation (1) was obtained independently of s, and can be established for cases in which Boyle's law holds, and, therefore, if one of its variables v/V becomes affected to such a large extent by including s, it would be expected that the third variable thereby introduced would, in general, considerably affect the form of the function, even though a large part of that effect becomes disguised in what appears an independent change of the variable v/V.

In equation (8) we may consider that we have the most general form of the resistance equation. It includes all that has been given in equation (1), together with the local heating effect previously discussed, and the effect due to the size of the molecules, the latter being one of the chief factors that affect the state of the fluid. It only remains to group the four variables in (8) in such a way as to give a form of equation suitable for practice. It is advisable for this purpose to retain our original variables v/l ν and v/V, and since local heating has been shown to affect the problem, we may take $\frac{Q}{K} \cdot \frac{v}{l}$ as another variable which represents one of the main factors influencing the resistance. The change of state has been shown to depend largely upon the constant b in Van der Waal's equation. This constant b is a third of the critical volume Sc of the fluid, and, therefore, this physical constant may be taken as the fourth variable and the term governing the effect due to state. Equation (8) can now be written—

$$R = \rho\,v^2\,l^2\,f_4\left\{\frac{v\,l}{\nu}, \frac{v}{V}, \frac{Q}{K} \cdot \frac{v}{l}, \frac{S_c}{l^3}\right\} \quad . \quad (9)$$

These four variables are, of course, not bound to be in the form here given. More convenient forms might be found, but they have been suggested because, in the author's opinion, they represent the main factors contributing to the resistance. The term $v\,l/\nu$ may be regarded as giving the effect produced by the value of the viscosity for the general fluid, while v/V chiefly represents the effect of compressibility as usually understood. $\frac{Q}{K} \cdot \frac{v}{l}$ is present in virtue of local heating, and its effect would conceivably be large both when considerable heat is produced and when a critical or practically unstable type of flow exists. This term is always liable to be present as an important term, whether the fluid be a liquid or a gas. The last terms S_c/l^3 may be supposed to represent the departure of the fluid from Boyle's law, and is chiefly affected by



the state of the fluid—liquid or gaseous. For gases properly so called, well above the critical temperature, and for vapours far removed from the liquefaction, this term may become unimportant, but for liquids, for gases situated near the critical volume and temperature, and for vapours, especially wet vapours, such as wet steam, fluid motion problems might be greatly affected by this term.

RISK AND REWARD.

He who hazards nothing plays for safety, and the reward is of necessity small. Safe employment at a fixed salary obviously is contingent upon market rates and upon the value of the individual to the employer, or better still perhaps, the fact that the employée convinces his employer of his value. In order to achieve monetary victory—economic independence—it is essential that some risk should be taken. Not that such risk is greater than that taken daily by many classes of workmen. Their risk is personal and human; the question of financial returns means financial responsibility. A large, and by no means an individually negligible, section prefer safety at all costs to a limited hazard for an increased return. Speculation in its adverse aspect is not the necessary alternative; but low interest is more or less consonant with security. It is the same in a personal sense as in the wider commercial aspect; it is, for instance, most often necessary to change employment more than once in order to obtain even due recognition. Time has a nasty habit of moving forward and the boy of yesterday achieves manhood almost unconsciously; even with an unblemished record it is difficult to make an employer realise the patent fact, difficult to make him see that in ensuring production he has also raised a man who requires a man's reward. When the situation becomes acute it is then necessary for the worker to insist upon the fact and in default of recognition to seek employment elsewhere. It is rather useless to expect other folk to notice individual conditions and unless personal effort is made to this end little can be achieved. It is rather remarkable, all things considered, that many men who are competent to plan and to contrive to "make good" in material matters, have usually no idea how to plan a campaign for their own individual advancement. Few even know how to state a reasoned case in an application on their own behalf either by themselves or through outside influence. We do not mean by intrigue, but by a method of approach which is likely to achieve its end without undue resentment on the part of the employer. The best men are often the least articulate when they are themselves the subject at issue; they will suffer under feelings of disappointment and even quit rather than ask for advancement.

One of the surest methods of losing the day is to be always bothering when there is no opportunity open. One of the safest of methods is diligent preparation on a settled plan towards a definite goal. Having the requisite qualifications the presentation of a proper case invariably secures consideration when opportunity arises. With an awkward gap to fill in the staff an employer usually finds it cheaper to promote a capable man on the staff rather than engage someone from outside, but because of his own ignorance of his own merit and often for want of due application and the display of suitable qualifications the staff-man misses his chance. It is quite realised that it is not the most confident man who is the most likely to prove successful, and it must be remembered that where an executive position is open the selection of a man of limited service is expensive. There is often entertained the idea that application for a superior post penalises the applicant, if he be unsuccessful. Such is really a false conception; if a man is convinced within himself that he "fills the bill," and his belief is well founded, nothing is ever lost by making the view known. It is difficult to get the first step upward from the rank and file; after this is accomplished anything is possible. There is no doubt, to use a well-worn phrase, a time to speak and a time to keep silent, witness the attention paid to the more silent individual when he does speak. The pause is essential in music, and silence is often a period of preparation for activity. It is tiring and shows a want of balance to fight every trivial issue; compromise must be effected, and when protest is made it is the more effectual if unexpected.

It is the man who calculates the risk and, having done so, is prepared to hazard—willing to lose the day—who is most often successful in almost every relation of life. This applies to promotion, to commerce, and to most other things. It is easy to play for safety, it means keeping still, taking no initiative, working on precedent; the trouble is that those who practice the safe game usually grumble loudest that success does not hunt them up. Many risks are daily taken which carry no inordinate reward; but where the risk is considerable and the reward negligible, there usually is honour which cannot be measured as consolation for the danger. The man who merely risks without due calculation, who is foolish enough to erect an edifice without a foundation, can, however, expect little sympathy in the event of disaster. He who buys pigs in pokes invests in Spanish gold. He who becomes a victim to the confidence trick is not merely a wild speculator but, expecting something for nothing upon grounds contrary to commonsense, is a fit subject for mirth, however painful the results may be to him personally. On the contrary he who plays first for safety, finding that adequate reward passes him by and then expects a sympathetic ear, is doomed to disappointment. He has safety—his prime consideration. What else did he expect? Opportunity came, but he was either not fitted or, since chance must be served by risk, refused the chance and consequently there are no grounds for complaint that a critic can see. The normal man refuses to speculate wildly or to avoid reasonable risk, but often enough fear keeps him virtuous. Afraid to put adventure to the touch he sees the opportunity but hesitates to seize it. On the whole the average man is too hesitant in matters where risk has to be taken with both hands for a reward after all only problematical. Few men are driven to success. Those who achieve it either made their own opportunity or placing all they most valued in the scale, moved boldly onward, conscious that the penalty for failure would be severe. A stimulus of this kind spurs the right type to superhuman endeavour, the wrong are crushed by the first reverse — the breath of difficulty chills their fortitude.

The reason why much industry has drifted into the hands of large organisations is not because the small man cannot compete, but largely because the vast majority of men prefer safety with its penalties to risk with its rewards. There is capital in character, investment in ability; a combination of the two may be expected to tide over difficulties. The man who takes risk with judgment can command capital in the banking sense, and the more successful he becomes the more readily can he command resources; money will then actually come and beg to be used. Men of inferior attainments—although sometimes not of the highest type of character, but having the commercial instinct,

adventure their all, and frequently prove successful in business of large scope. It is lamentable but true that assistance playing for safety can be hired at a cheap rate; ability is by no means uncommon, character is far from rare, but the spirit which takes risk and which adventures is certainly far from usual.

Every man met with, receives from you an impression, it may be distinct, definite and lasting, it may be composite and progressive, or it may be adverse. A superior cannot help it, he must be impressed if only to consider you negligible or merely fit for routine and ordinary employment. Some men give a distinct impression of vitality, of alertness, some of reflective capacity; some appear to have no interest in life at all; the point is that all convey some impression. Cumulative impression of a favourable character on a superior is extremely valuable if advantage be taken at the moment opportunity offers. There is sometimes, it is feared, a desire to retain an employee, only because he fills his post most successfully and there is no one in sight to replace him. This brings another factor into view—the necessity for an adequate reinforcement to step up into one's own shoes if necessary. Few men are big enough to realise this fact and fear their own supersession (playing again for safety) indicating a want of belief in their own abilities. To the man of critical mind in command praise of a junior is always welcome, since it indicates the calibre of the senior man.

There is altogether too little adventure in normal industry, it is always easier to lie low, always difficult to be aggressive, to risk, or to grow. Progress is always allied with growth. Standing still means going backward. If we desire reward we must each take risk, adventure to the proof. Success depends as much upon the right spirit as upon following out copybook platitudes, praiseworthy in themselves, but their effect alone will never compass competence.

RECENT MACHINE TOOL DEVELOPMENTS.—No. IX.

By JOSEPH HORNER.

Drilling Machine Tables.—The tables of drilling machines are of a more simple character than those of milling and slotting machines. These usually have two slides, longitudinal and transverse, and very frequently a circular table also with circular motion. These, being superimposed, throw much weight on their supports, so that in the heaviest machines it becomes a problem how to afford adequate stability to the knee. In slotting machines this is solved by fitting the saddle to a horizontal slideway which goes to the ground. In heavy milling machines the knee must have a supporting elevating screw, or a pillar, or a brace of some kind; often both in combination, a brace above and a strut below going to the foot of the machine. Stability is also favoured in all cases by giving ample width and length to sliding surfaces, worked out differently in different designs, with the object of preventing tilting and lateral movements under heavy cutting.

Though simplicity is desirable in machine tools, general utility is more essential in the great majority that have to perform various services in all shops except those where the work is entirely specialised. This does not mean that a machine need be of a universal character, but rather that it should be capable of dealing with a variety of articles to be operated on by one group of tools used in that machine. This is a wholly different thing from including several different operations requiring distinct groups of tools, or even operations with the same group of tools, but of a radically different character. With regard to a machine restricted to slotting or to milling of one kind, or to a shaping machine, or one class only among the numerous drilling machines, a noticeable feature is the adaptation of the machine for dealing with a variety of work to be tooled in one fashion. The variations deal with the handling of work in a considerable range, the tools remaining of one kind. This explains the reason for the fitting of compound tables in so many machines, and for circular tables in large numbers. These are supplemented more extensively than ever with machine vices to receive articles that are better held thus than directly on the tables. These vices now include a large number of varieties, suitable for holding shapes parallel and tapered and cylindrical, and at various angles.

Some selected examples of tables for drilling machines are given in this article, ranging from those of a very elementary character to tables highly elaborated, including power operations. No machines manifest greater variations in design of table than the drilling machines do. This is not surprising when we remember how varied are the shapes and masses and depths of the pieces put on them, and the fact that drilling is done at all angles, and that most machines have to take a general run of work.

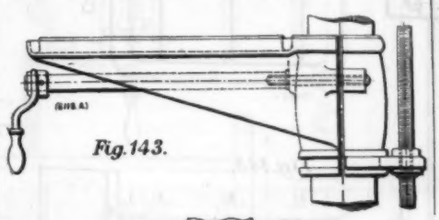


Fig. 143.

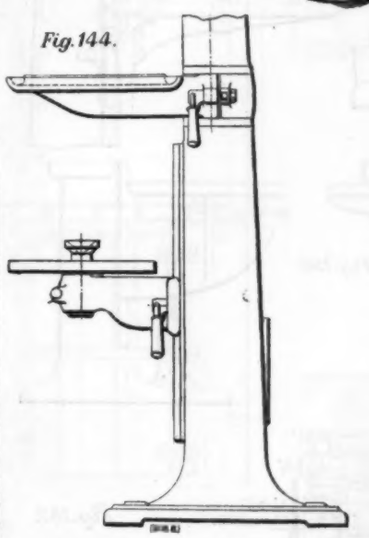


Fig. 144.

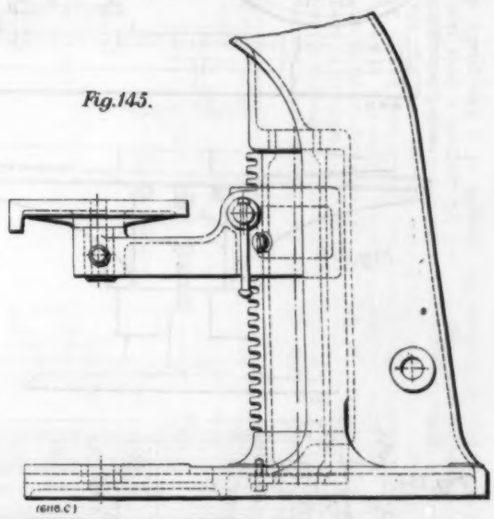


Fig. 145.

A light table for a sensitive drilling machine is shown by Fig. 143. The method of elevating adopted is somewhat unusual. A long screw is stepped into the base of the column and is embraced by a nut with a fork that enters the cap portion of the split boss of the table that grips the column. The screw is turned with a hand wheel above actuating mitres (not shown), so raising or lowering the knee. It is then clamped on the column with one screw tightened by means of the lever at the front. This lies to one side, that where the split occurs. The face of the table is 18¾ in. square. It can be slewed round the column to any angle in plan.

The fitting of two tables to a sensitive drill is shown by Fig. 144. The lower table, circular in plan, 11½ in. diameter, and clamped with a stem in its knee, slides vertically on the face of the column. The upper table, 21 in. square, remains at a uniform height, but it can be slewed with the work that it carries, and be clamped by means of its split boss, or be turned aside to permit of using the lower table. The latter is fitted with a hollow cone to centre shafts to have their centres drilled.

An unusual table fitting is shown by Fig. 145. It belongs to a vertical drill, adjustable vertically on, and slewing round a cylindrical pillar. The table is square, and is secured in the arm at any plan angle with a set screw. It is elevated with a pinion and rack of 1 in. pitch, the rack moving round the column with the plan adjustments of the table. The square table, which is provided with slot holes for bolts, can be slewed on its knee, and clamped.

Fig. 146, on page 104, shows a 24 in. circular table for a drilling machine, having a long cylindrical stem fitting in a knee in which it can be rotated and clamped. The knee is carried on the cylindrical pillar of the machine with a boss divided in two parts, one half being cast with the knee, the other forming a cap, the two being secured with four bolts which also tighten them on the pillar. The height of the knee is set with worm gear, pinion and rack, as indicated. The knee can be slewed laterally, since the rack can move round the pillar with it. Deep articles can then be put on the base. The plan of the table looks at it from below, and shows the annular support afforded, and the slot holes for the bolts.

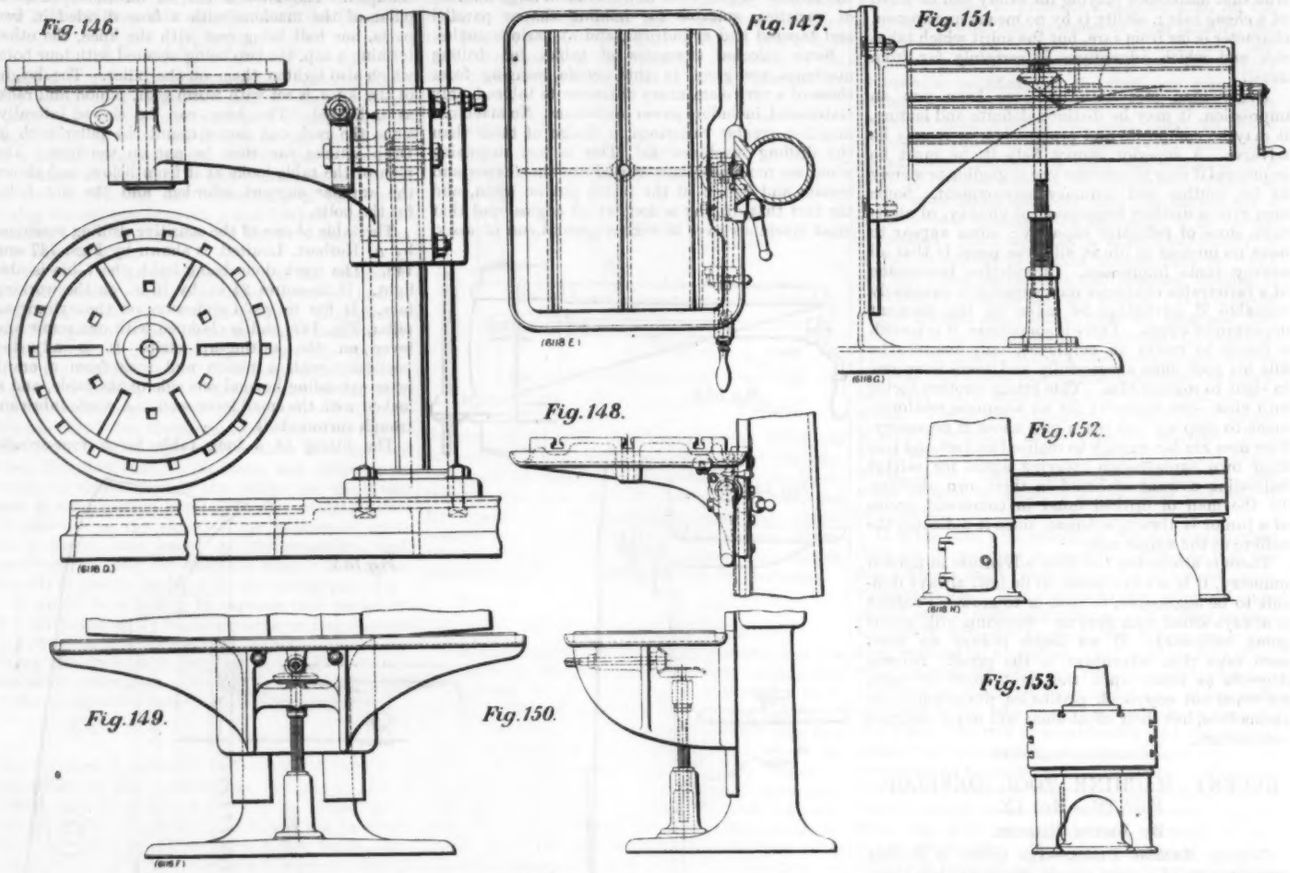
The table of one of the sensitive drilling machines by A. Herbert, Limited, is shown by Figs. 147 and 148. The work done being light, the table is also light. It measures 24 in. by 16 in. on the working face. It fits to vee'd slideways on the cylindrical pillar, Fig. 147, and is clamped with one screw and lever on the setting-up strip. It is adjusted vertically with a pinion and rack from a crank lever extending beyond one side of the table, and is locked with the small lever seen. A waste lubricant trough surrounds it.

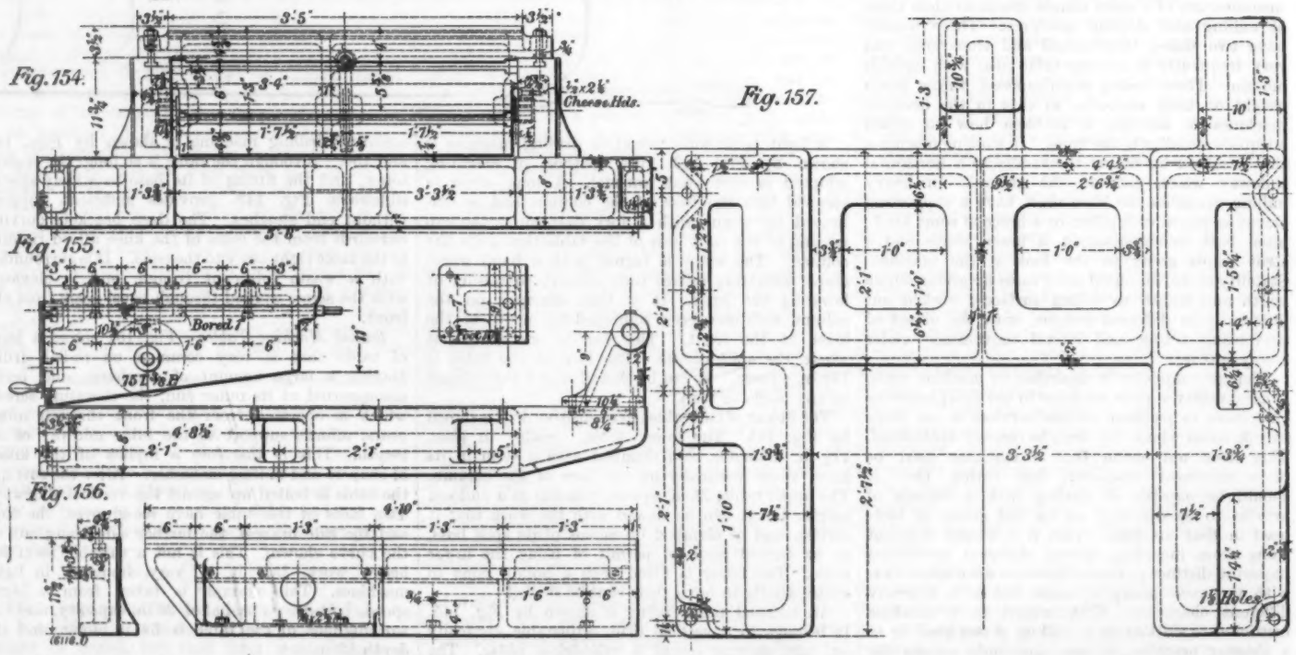
The fitting of a long table for a four-spindle sensitive drilling machine is shown by Figs. 149 and 150. Although the table is so long, the central screw, and the fitting of its base to widely-spread slideways, Fig. 149, provides sufficient support without end steadies. The deep brackets curving outwards from the sides of the knee afford rigidity to the table right away to the ends. It is surrounded with a waste lubricant trough, and is elevated with the screw worked through bevel gears from the front.

Radial Machine Tables.—Fig. 151 shows a form of table that is very common on radial drills. Having a large amount of overhang, and being unsupported at its outer end, the elevating screw, which is operated from the front through mitre gears, affords support to the table midway of its length. This is therefore a replica of the knees of shapers and milling machines. After the setting, the table is bolted up against the vertical slideway. Two faces of this table have tee-grooves, the top, and the side nearest, the farther side being cut to the curve shown. This is not a suitable form for heavy work, but it is very frequent in light machines. This example is taken from a high-speed, belt-driven radial of 36 in. capacity, and the working face of the table is 34 in. long, and its depth 12 in.

Figs. 152 and 153 illustrate a table of rectangular form fitted to a medium-size belt-driven radial drill. It is rigid, being cast in one with the base that supports the column, and which is carried on the cabinet foot at that end. It is extended in width from the base, as indicated in the end view. The foot at the outer end extends nearly to the increased width. The advantage of being able to bolt work

RECENT MACHINE TOOL DEVELOPMENTS.

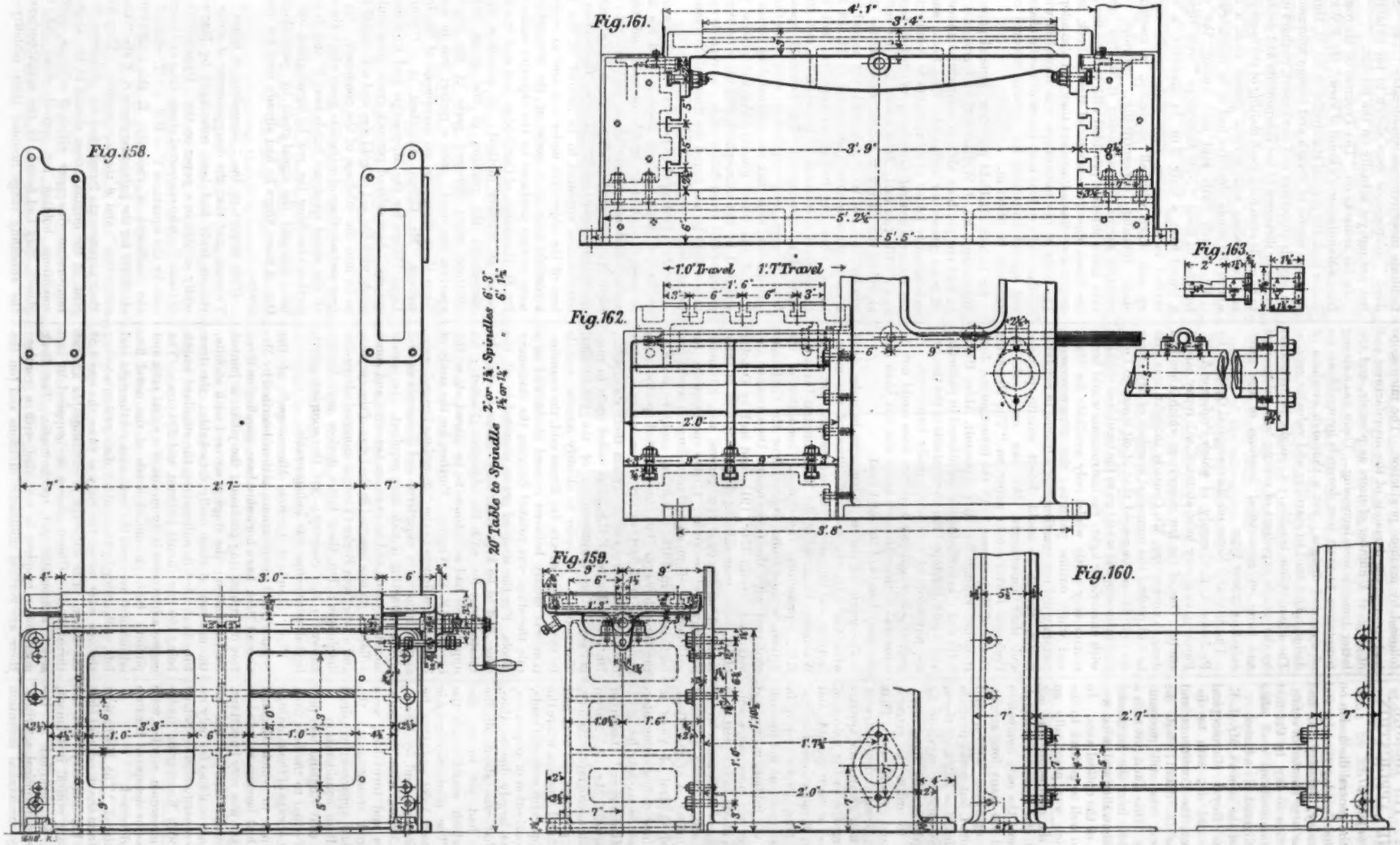




on three faces, and over a considerable width is possessed in this design.

Tables for Multiple-Spindle Machines.—Figs. 154 to 156 illustrate the table fitting of one of the Webster and Bennett two-spindle drilling and boring machines. Included is the base casting, Fig. 157, on which the uprights, and the brackets that support the table, are mounted. The base, Fig. 157, is a single casting. E-shaped in plan, carried back to receive the uprights, which are like planing-machine housings in outline. They are connected at the top with a stretcher bar, that carries driving gears, and elevating gear similar to that of planers, for making vertical adjustments of the cross rail which carries the saddle for the drilling spindles.

The work table is supported on two brackets—the table slides—Fig. 156, that are bolted to the base. The table fits these by guiding surfaces on the ends, and with flanged extensions on the top, Fig. 154. It cannot, therefore, be subjected to any diagonal twist when being moved, and it is amply sustained in the vertical direction. As the working face of the table is 41 in. long, to correspond



with drill spindles having maximum centres of 39 in., it is moved crosswise with duplicated racks and pinions, Fig. 154, lying within the supporting slides. These are actuated simultaneously with a lever handle at the front, Fig. 155, turning a worm-shaft which rotates a worm wheel on the centre of the shaft on which the rack pinions are fastened. The table has tee-grooves on the top and front face. When the work is bolted to the front vertical face of the table the cross-movement of the table is operated by means of the table crank on a square at the near end of the wormshaft, Fig. 155.

For multiple drilling machines, a table that slides longitudinally to bring, when required, fresh sets of holes under the drills is useful. One of this design, by Messrs. Webster and Bennett, Limited, is shown by Figs. 158 and 159. It is mounted on a deep base that encloses two separate cupboards fitted with wooden shelves. The base is bolted to the front of the uprights, securing them there, while at the rear they are stiffened with a distance-piece, Fig. 160. The sliding table is fitted to the top of the base with vee'd edges. It is travelled by hand wheel and screw. An adjustable stop arrests its movement for repetitive drilling. It has 4 in. of travel, using the stop screw, and 12 in. of total travel. The stop screw is seen below the table screw, Fig. 158. The table is surrounded with a waste lubricant trough.

Figs. 161 and 162 illustrate a table that slides between the columns of a two-spindle drilling machine, to permit of pitching holes in the transverse direction. The supporting brackets are bolted to the faces of the housings, and to a baseplate beneath, which is also bolted against the columns. The table slides against vertical faces and is carried on four horizontal rollers running on pins, shown separately in Fig. 163, in the columns, when it is run backwards to allow large pieces of work to be bolted to the base. It is actuated by a long central screw working in a nut, and turned with a crank handle.

THE MICROSCOPE: ITS DESIGN, CONSTRUCTION AND APPLICATION.

(*Concluded from page* 87.)

LAST week's account of the general discussion on the Microscope, held by the Faraday Society and cognate bodies on Wednesday, January 14, had to be confined to a few of the large number of contributions presented. We notice to-day, in the first instance, the general communications read after Sir Robert Hadfield had delivered his address.

Giving a general survey of the subject, Mr. J. E. Barnard, president of the Royal Microscopical Society, remarked that he did not wish to discuss the differences between the Continental and British microscope stands in detail; but, he pointed out, the microscope was still mechanically and optically unstable. One could not turn a microscope from the vertical into the horizontal position without disturbing centrality and, what was more serious, the alignment of the optical axes. In many respects we should do well to go back to the English type of 1841 which was practically an optical bar. Mechanically the microscope had not been much improved, and the Rosenhain metallurgical microscope was almost the only innovation of late years. We had still too many long screws. As regards the numerical aperture, $n \sin a$, and resolving power we were limited, but could progress by increasing the n, the refractive index, or the a, half the apex angle of the cone of rays, or by diminishing the wave-length of the light used. Some day we might learn to utilise the extreme ultra-violet Schumann rays and even X-rays. That was not an idle dream. Mr. Barnard demonstrated with the aid of many slides how greatly the appearance of low organisms changed with the nature of the illumination (transmitted or dark ground) and with the selective absorption of radiations of special small wave-lengths. His photographs taken in ultraviolet light showed that much of the internal development brought out by the ordinary microscope might be spurious, whilst certain membranes were really double. These specimens were certainly remarkable, and the fine series of slides which Mr. A. Chaston Chapman, F.I.C., subsequently exhibited in demonstrating "The Application of the Microscope to the Selection and Control of Yeast in Brewing," further proved how difficult the interpretation of microscopic phenomena may be.

In his "Notes on the History and Design of Photomicrographic Apparatus," Mr. F. Martin Duncan, president of the Photomicrographic Society, pointed out that the pioneer photographic work had been done in France, England and America, where the most perfect micrographic apparatus were still made. He admitted that the high perfection of objectives, eyepieces and substages was largely due to Abbe, Schott and Zeiss; but that was about all the German contribution. He had yet to see the Continental model stand which would touch the best British production. The photomicrographic cameras brought out between 1889 and 1893 by Messrs. Swift and Mr. A. Pringle, and by Messrs. Baker and the late Lees Curties, with their substantial baseboards, bellows and turntables, were superior to the German rod arrangement; the design of a good rigid vertical apparatus remained a matter for serious immediate consideration.

Sir Herbert Jackson said that England was producing optical glass at least equal to the best from abroad, but the glass was not always of the same high accuracy. As to microscopes, in which England had once been leading, we had become satisfied to follow. The educational aspect was very important. The spectroscopist was trained how to use his spectroscope; the microscopist could so far only receive such instruction in the recently-created School of Technical Optics at South Kensington under Professor Cheshire, and microscopic studies were often abandoned as fruitless or deceptive because the phenomena were not understood.

Prof. F. J. Cheshire considered "The Mechanical Design of the Microscope," from the standpoint that the optical industry was a key industry, and the microscope the most important optical instrument, the production of which he regarded as the touchstone of national success in optical activities. In the development of any mechanical invention the artistic production of the early days had to be followed by machine production. The microscope had to meet the demands of the manufacturer and of as great a number of users as possible, and the latter demands were increasing. There was a strong temptation to meet new demands by modifications of approved designs; yet a thorough overhaul of design might lead to startling and valuable results. The illumination trouble, *e.g.*, might be overcome by the simple expedient of resting both microscope and lamp on geometrical bearings of the three radiating-groove type.

The critical "Notes on Microscopical Optics," by Professor A. E. Conrady, of which Professor A. W. Porter gave a very brief abstract, will repay careful study. One of the few disservices which Abbe had done to microscopy, Mr. Conrady thought, was that he had pushed the numerical aperture of dry lenses up to 0·95 and increased that of oil lenses to 1·40. Few microscopists would go to the trouble of working with ultra-violet light; the instruments would hence remain very costly whilst only available for black and white outline pictures; the ultra-microscope certainly did not constitute an advance in resolving power, though it could detect minute particles and their movements. We can only refer to Professor Porter's own paper on "The Resolving Power of Microscopes." Of the investigators, John Herschel, Fraunhofer, Airy, Foucault, Abbe, Helmholtz and Rayleigh, the last-mentioned in particular had chiefly developed the physical side of the theory; the physiological side was equally important. In general one might say that two lines could not be separated if their distance apart was less than half the wave-length of the light used.

The group of papers taken next in order dealt with the interests and difficulties of the manufacturer and the user of the microscope. Dr. R. M. Walmsley, Principal of the Northampton Institute, E.C., representing the Optical Committee of the British Science Guild, related how the Guild had conferred with the Government Departments and manufacturers in May, 1915, and had by October of the same year submitted specifications of three types of microscopes (for general use, advanced petrology, and research); further specifications (for pathological, chemical and metallurgical work) had been issued in 1916. Nothing could be done at the time, however, but the amended specifications would be published within a few weeks. Before the manufacturers could explain their standpoint, Dr. J. W. Evans, F.R.S., was called upon to summarise "The Requirements of the Petrological Microscope." In order to identify minute crystals by their optical effects, Dr. Evans said, the examination was mostly between crossed nicols, and as a rule the stage was rotated between the stationary nicols. For the study of grains mounted in oil, the stage had to be kept stationary, unless it could be rotated together with the objective (Nachet); an upper nicol had sometimes to be placed above the eyepiece (F. E. Wright). Further, for the study of interference figures in the "directions image," wide-angled immersion objectives and illuminations and highly refracting liquids were required. To isolate minute crystals and to examine twinning and zones a diaphragm was inserted in the focus of the eyepiece and a lens from Becke (Vienna) mounted above the diaphragm; but these latter devices were hardly known in this country; yet the complex petrological microscope was indispensable.

The "Standard London Microscope" of the Science Guild specifications, as then described by Mr. Conrad Beck, has a horseshoe base, standing on three feet on rubber-ring cushions; the pillar is jointed for inclination; the stage is covered with ebonite, the mechanical stage easily detachable; the draw tube is divided in millimetres, the standard length being 160 mm. (limits 140 mm. and 200 mm.). The coarse adjustment is by means of a spiral rack and pinion; both the milled heads of the novel fine adjustment are upon the same axis, on the right and left, each acting by the contact of a screw on a lever; the one lever moves the body at twice the speed of the other. The substage is exchangeable against three others. Object glasses are supplied in two series, achromatic and apochromatic. The Beck micrometer eyepiece is provided with a vernier; there are vertical millimetre divisions and (on the edges) horizontal half-millimetre divisions, which facilitate measurements considerably. The "Standard" microscopes were shown in the exhibition, but are not yet actually on the market.

In his remarks on "The Progress of Microscopy from a Manufacturer's Point of View," Mr. F. Watson Baker took the general standpoint of Mr. M. Duncan as to the merits of British and foreign microscopes. As regards objectives and condensers, changes in the curves or distances of the components had generally to be made even for a fresh melting of the same glass, and in dealing with several glasses from a fresh source the whole objective had to be reconstructed.

Mr. Powell Swift said that among the chief features of their "New Microscope" were rigidity, a tripod base, a body 2 in. in diameter, a stage carried in a massive right-angle cradle racking up and down with all apparatus, a mechanical stage rotating concentrically, provided with centring screws for adjusting it to the optical axis, and a substage provided with two cradles as in the Sloan objective changer of Messrs. Beck, whose double-lever fine adjustment they had also adopted. The body of the microscope was furnished with a similar cradle so that nose-pieces of special character and special apparatus for various research could instantly be fitted in.

Sir Robert Hadfield put these general papers to discussion. Mr. J. William Gifford mentioned that he had not yet been able to compute combinations of three glasses for sufficiently long focus, and he subsequently joined other speakers in comments on the claimed general superiority of British productions. His two early Zeiss lenses had not suffered at all in the course of years. Commander M. A. Ainsley, R.N., of Woolwich, said that he had found a Swift aprochromat quite equal to his 18 Zeiss lenses; but the British average was not high, the perfection reaching 95 per cent. in, say, 10 per cent. of the production. Dr. Bousfield, speaking from a very long experience with Lees-Curties instruments, said that the original Jena lenses had been of the finest quality, but the glasses were attacked by the atmosphere, and the substitutions provided had given flatter fields; as regards curvature of field he had found the lenses of Neuhaus, of Berlin, best.

For the "Testing of Objectives," Mr. F. Twyman, of Messrs. Adam Hilger, recommended his interferometer method in which, he said, microscope makers had not so far taken any interest; the method is used at the National Physical Laboratory, as we have mentioned. In this instrument the interferences appeared to be located on the back lens of the objectives under test and to represent a contour map to a scale of the aberrations of wave surface produced by the objective under test. Dr. H. Hartridge, of Cambridge, had sent in a short paper on another method; he measures with a micrometer the position of the image pattern obtained when different parts of the objective aperture are used; with a perfect lens in correct focus there should be no movement of the image pattern. Mr. Gifford described, in a "Note on Light Filters for the Microscope and Photomicrography," how cells of peacock-green glass could be made with the aid of gold size and soft metal rings to fit into the substage of the condenser. He had first used solutions of malachite green which absorbed all the visual spectrum bands near F and B (red), further absorbing the red by signal-green, and had later replaced the signal-green by peacock-green. One of these filters he had already used for twenty years.

With respect to the "Annealing of Glass," Mr. Twyman said that the disappearance of stress in a viscous body had been considered by Maxwell—oddly enough in a paper on the "Dynamic Theory of Gases"—who connected stress, time and temperature by the equations $F = E S . \epsilon^{-\theta/T}$, where F was the coefficient of viscosity, E the coefficient of elasticity for the particular stress S, T the "time of relaxation" and θ the temperature. They had in their experiments found that for glassware 95 per cent. of the original stress should at the annealing temperature disappear within 3 minutes, modified conditions holding for optical glass. All their glasses, they had found, in the neighbourhood of the annealing range doubled their mobility—the

reciprocal of viscosity—for every 8 deg. C. rise of temperature.

Dr. W. E. S. Turner's "Note on Optical Glass" contained the statement that America was still far behind England in the manufacture of optical glass, and that in the last few months all the plants—except that of the Spencer Lens Company, Hamburg, New York, and the experimental plant of the Bureau of Standards, Washington—had been closed down; thus English glass would find a market over there. Dr. Turner also mentioned that he had received a beautiful specimen of calcium fluoride from Johannesburg. On this point Mr. R. L. Mond, M.A., offered a short communication; a search for colourless fluorspar made in Canada showed that this mineral—valuable because it, almost alone, is transparent to Schumann rays—seemed to be very rare.

Dr. A. E. H. Tutton, F.R.S., drew attention to the valuable aid that the "Grayson Rulings," of up to 120,000 lines to the inch, could render in studying high resolution and in actual calibration and measurement; Professor Grayson having recently died in Melbourne, it was to be hoped that Melbourne University should keep his ruling machine available for the production of Grayson rulings. General notes on "The Future of the Microscope" were presented by Mr. H. Le Chatelier and by Mr. Eugène Schneider, of Creusot; the latter also exhibited a microscope for measuring Brinell impressions constructed by the Société d'Optique et de Mécanique de Haute Précision, of Paris.

We also notice a paper by Mr. R. J. E. Hanson, F.R.C.S., on "Fatigue Factors Incidental in the Use of Certain Optical Instruments." He exhibited working models of a headpiece attachable to any standard tube microscope without necessitating structural alterations, though he intended to arrange a bracket with attachment at or below the trunnion in new microscopes. This "dyoptikon" is a sliding head rest with rubber tubular buffer to lessen fatigue and mal-orientation of the eyes; the eyes may be used alternately, and neither eye need be closed.

The last, large group of papers discussed was that of "Metallurgical Microscopes." Dr. W. Rosenhain, first called upon, explained that the microscope should be rigid; it should dispense with all avoidable parts, *e.g.*, the coarse movement of focusing the body tube. Working with ultraviolet light was laborious, the results seemed not very satisfactory, and there was much internal scattering and fluorescence within the tube and at the back of the objective. The source of illumination should have a reasonable area (2 cm. diameter) and be so placed behind ground glass or an opal shade opposite the instrument that the distance of the source from the illuminator mirror was equal to the distance of that mirror from the back focus of the objective; only an iris diaphragm was then required just outside the illuminator aperture. The lamp was in his microscope (Fig. 7) mounted with a short tube in a ventilated case; pointolite lamps so far did not offer sufficiently large areas. As regards the fine focusing of the microscope when used for photographic purposes he had devised the arrangement illustrated in Fig. 8 to avoid all the lateral pull generally accompanying the use of gearing or cords. The focusing rod extending along the camera was connected by pulleys and a belt with a rotating spindle which had its independent bearing, but was always axial with the fine adjustment of the microscope. Near its end the spindle carried a small cross rod, which in our Fig. 8 is seen just protruding from one of the two longitudinal slots, diametrically opposite one another in the light tube; the latter was fixed to the fine adjustment head. When the operator turned the focusing handle, the cross rod merely turned the adjustment without displacing it; the rod being less wide than the slot, and the belt slightly elastic, the rod and spindle sprang back as soon as the operator's hand was removed, and the rod was brought out of contact with the tube; thus the microscope was left entirely free from contact with the focusing gear. The tube was given a certain length, so that the fine focusing adjustment could be moved through a considerable distance by the coarse focusing of the stage.

Most of the other contributors of papers made detailed suggestions for the Design and Construction of Metallurgical Microscopes. Professor Cecil H. Desch said he had often found British design and workmanship to be good, but the instruments were apt to fail in long service, racks and screws worked loose, probably because the brass used was too soft; the provision of adjustment screws, which his Zeiss instruments did not need, was itself a confession of weakness. For vertical illumination he preferred a disc to a prism; on this point we shall have more to say on another occasion with respect to a paper by Messrs. Carl Benedicks and Erik Walldow, of Stockholm, on "High Magnification Micrographs," which arrived too late for presentation at the meeting.

Further general papers on metallurgical microscopes and photo microscopes were presented by Messrs. Leslie Aitchison, D.Met., and F. Atkinson; by Mr. J. H. G. Monypenny; by Dr. F. C. Thompson; by Mr. Henry M. Sayers; and by Messrs. J. R. E. Slade and G. I. Higson (especially on illumination). Descriptions of new microscopes had been sent in by Professor F. Giolitti, by Professor Albert Sauveur (made by the Bausch and Lomb Company, of Rochester, New York), and by Mr. A. Silverman (illuminator). A very simple workshop microscope was exhibited by Dr. J. E. Stead, F.R.S. The chief feature is that there are two objectives, one of low power, the other of high power, sliding horizontally at the lower end of the tube; when the object, underneath both of them, is focused for one of the objectives, and the slide moved, the object remains in focus for the other objective. The illumination is by a small electric lamp mounted in a horizontal tube; the light falls on a disc, inclined at 45 deg., which reaches half-way into the illuminator tube. The dry cell and switch of the instrument fit into the pocket, and the microscope itself into a small box.

Finally we may mention papers by Mr. S. Whyte, of Redhill, on "The Use and Need of the Microscope in Engineering Works," and by Dr. R. S. Willows, on the "Microscope Outfit of a Textile Research Laboratory."

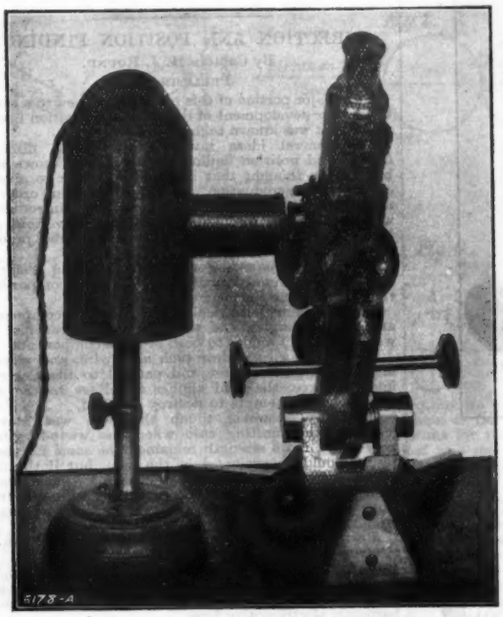


FIG. 7. ILLUMINATOR FOR METALLURGICAL MICROSCOPES.

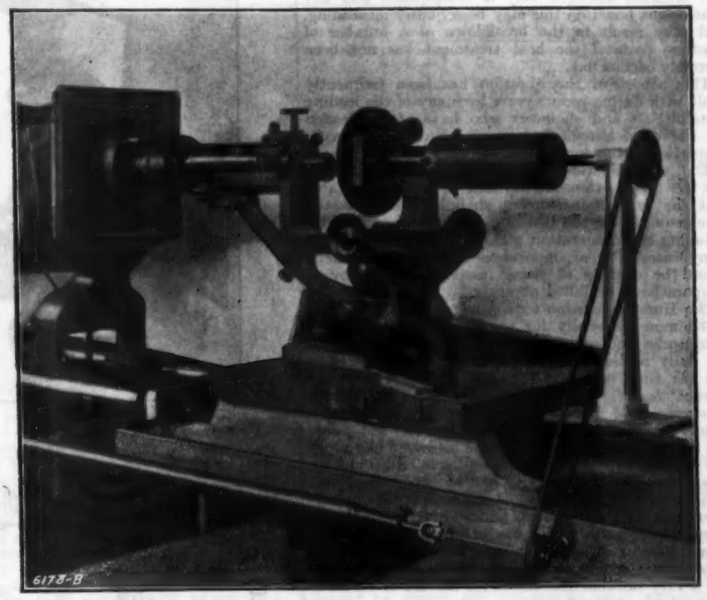


FIG. 8. FINE FOCUSING ARRANGEMENT FOR CAMERA.

CONTINENTAL TRADE FAIRS.—According to *The Board of Trade Journal*, full particulars are now available regarding the forthcoming International Fair at Milan. The 1920 Fair will open on April 1 and run for a fortnight. The organisers are erecting huts, which measure 3·5 m. square, to be let to foreign exhibitors at 1,450 lira per stand. Twenty of these are placed at the disposal of Great Britain. The Italian Government is considering the question of freight and Customs facilities for visiting exhibitors. The Central Powers are ruled out by the regulations of the the fair, and only allied or neutral firms may exhibit. Amongst the trades for which there are specially good openings for forming a British market are textiles, chemicals, machinery, stationery and raw materials. The organisers hope in future to hold spring and autumn fairs annually. The committee appointed at a recent meeting of the Chamber of Commerce to inquire into the location and organisation of Swedish Trade Fairs has now drafted its proposals. This committee, it is stated, have circularised interested parties, and the majority of the latter are in favour of holding only one fair for the whole of Sweden—this fair to be held in Gothenburg. The committee have adopted these recommendations, but, in view of the fact that preparations are now well advanced for holding next year fairs at Sundsvall and Malmo, have decided that the new organisation shall not come into force until 1921.

THE HURST-TOMLINSON EXTENSOMETER.

EXTENSOMETERS have hitherto been seldom used in the routine commercial testing of the properties of metals used in engineering construction, and until recently it has not been considered necessary to include any determination of the elastic limit of the test-piece.

The omission of the elastic limit determination is fairly satisfactory so long as the number of different materials in ordinary use is limited to comparatively few and their elastic properties are well understood. Thus, for example, in testing a piece of mild steel, the general type of relation between stress and extension is so well known that sufficient information could be obtained by measuring the ultimate stress and in some cases perhaps also a rough estimate of the yield-point by means of a pair of dividers.

Within recent years, however, rapid progress has been made in metallurgy, and many new varieties of special steels and alloys have been introduced which have such valuable properties that they have rapidly come into very general use. Many of these new materials have to receive special heat treatment, which greatly affects their elastic properties, and it is highly important that every test should include a reliable measurement of the elastic limit. A measurement of the ultimate strength only is inadequate, and any conclusions based on this may be seriously misleading, and may result in the breakdown of a number of machine parts if the heat treatment has not been correctly carried out.

This aspect of the question has been frequently dealt with during recent years by many of the leading metallurgists and engineers who have often pleaded for the more extended determination of the elastic properties in the commercial testing of steel.

The determination of the elastic limit involves the use of an extensometer, and it is very desirable that the type of instrument shall be such that the time required for the test is not unduly increased by including the observation of the elastic limit, and in many cases it is of importance that the instrument should be capable of being used efficiently by a comparatively unskilled observer.

The Hurst-Tomlinson extensometer has been introduced more especially for use in commercial testing laboratories and engineering works laboratories where the daily routine involves a large number of tests and the time necessary for each test is a very important factor. The object has been to produce a strong and durable instrument which can be rapidly attached to and detached from the test-piece, and by which the extension can be measured as simply and directly as the corresponding load. At the same time the degree of sensitivity and accuracy which has been found by experience to be desirable in an extensometer has been maintained, and the instrument is in every respect suitable for use in more detailed tests of materials or in special investigations of the elastic properties. Also owing to its simplicity and robustness it is a very suitable instrument for the use of students in engineering laboratories.

The Hurst-Tomlinson extensometer herewith illustrated is adapted for use on a specimen 2 in. in length, as this is the length most frequently employed in commercial testing. It can, of course, be attached to specimens of any length greater than this if required. Specimens of any diameter up to 1 in. can be used.

The extension of the test-piece is measured by a well-known high-grade dial indicator, which is actuated by a compound lever which magnifies the actual extension of the 2 in. length in the ratio of 10 to 1. The scale of the indicator is graduated in thousandths of an inch, so that one division corresponds to an extension of 0·0001 in. and by estimating to a fifth of a division the extension can be readily measured to the nearest 0·00002 in. The instrument is thus very sensitive, while at the same time it is direct reading, and the observation of the extension can be made in the minimum time.

A special feature of the extensometer is the method of procedure in attaching it to the test-piece. This is so designed that it is only necessary to place it against the specimen and tighten up the clamping screws and the points of the screws will be correctly placed 2 in. apart, and all lie in a plane through the axis. Thus the test-piece requires no preparation to receive the extensometer such as marking out the position of the centres with a punch. The time necessary for attaching the instrument is in this way reduced to only a small proportion of the total time required for fixing the test-piece in the testing machine. When the extensometer is not actually in use, as during the process of attachment or removal, it forms one rigid piece, and is therefore very easily handled.

Referring to the illustrations of the instrument, Figs. 1 to 3 on this page, it will be seen that it is provided with two forked levers and fitted at the fork with pointed clamping screws which, when tightened on the test-piece, form the pivots of the levers. The dial indicator is attached to one end of the upper lever A, and the other end, beyond the test-piece, has a stout vertical lug extending downwards from one extremity of the fork nearly to the level of the lower lever B. Here the lug bends inwards, and one arm of the fork of the lower lever extends inwards in the same way.

The two levers are connected by a short length of piano wire C, which lies in the central vertical plane of the two levers. This forms an elastic hinge, so that as the test-piece stretches the free ends of the levers open away from one another. This method of connecting the levers also permits the test-piece to straighten out slightly under the load, if originally slightly bent, without straining the extensometer. The lower lever is shorter than the upper one, and it carries at the free end a short vertical screw D with a large milled head.

The end of this screw is rounded and polished, and bears on the end of the shorter arm of a third lever E, which is attached by a short length of flexible steel ribbon to a bracket which is screwed and dowelled to

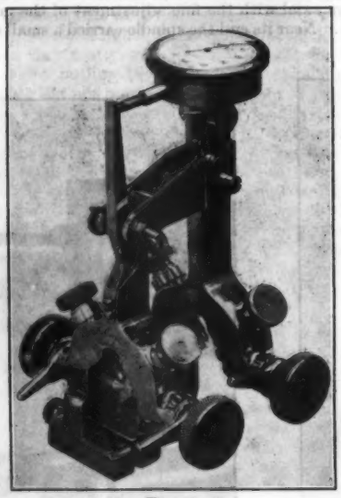
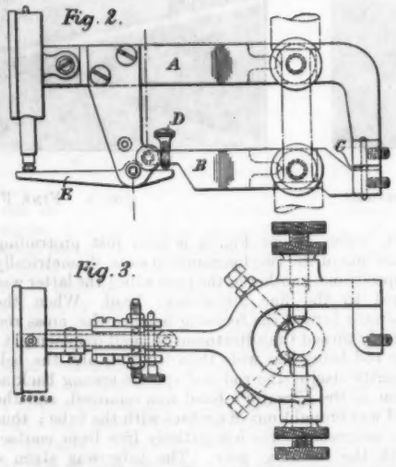


FIG. 1.



the upper main lever. The end of the longer arm of this third lever bears upwards on the end of the plunger of the dial indicator. The system of levers is proportioned so that the movement transmitted to the indicator is 10 times the extension of the test-piece. By turning the milled head of the screw the dial indicator can be brought to zero before the load is applied, a light spring maintaining the end of the small lever in contact with the point of the screw. While the extensometer is being attached it is necessary for the two main levers to be rigidly locked with the axis of the clamping points parallel and at a distance of 2 in. apart. This is accomplished by inserting two locking pins, not shown in the drawing, one of which constrains the axes to be parallel, while the other fixes the distance between them. The first pin is placed in the same horizontal plane as the wire hinge and its axis intersects the centre of the wire so that the insertion of this pin leaves the levers only one degree of freedom. The second pin correctly fixes the relative positions of the two levers.

In order to ensure that the clamping points shall grip the test-piece along a diameter and not along a shorter chord, two bearing screws are placed in the forked part of each lever inclined at about 45 deg. The usual diameter of the reduced part of the test-piece is 0·564 in., which gives a cross-section area of ¼ sq. in., and the length of the screws is such that when just tight the ends are 0·282 in. away from the vertical plane through the clamping points.

When attaching the extensometer it is simply held up against the test-piece bearing on the ends of the four bearing screws, and the clamping screws are tightened, the points then piercing the test-piece along two diameters. The extensometer is thus a self-contained marking-out jig. As soon as the instrument is fixed to the test-piece, the four screws are very slightly slackened so that they are just clear while the test is being made.

In order to render this device applicable to other diameters of specimen if required, the four bearing screws are each provided with a short sleeve under the head, which can easily be replaced by other sleeves longer or shorter, according to the diameter of the specimen. The instrument is being manufactured by Charles W. Cook, Limited, the University Engineering Works, Manchester.

DIRECTION AND POSITION FINDING.*

By Captain H. J. ROUND.

PRELIMINARY.

THE major portion of this paper is confined to a sketch of the war development of direction and position finding as far as it was known to me.

The general ideas involved in wireless direction finding and position finding are fairly well known now, but I have thought that it would be better to give an elementary introduction to the subject in order to make the paper more complete. This introduction will simplify the discussion afterwards of various side issues which have become important in the practice of the art.

General Reception.—For consideration an electrical wave can be divided artificially into two components, the electrical and the magnetic components.

In an ordinary electrical wave these two components are at right angles, and the direction of travel of the wave is at right angles to both of these components.

If we take a conductor such as a wire, and place it in the field of the wave and parallel to the electrical lines of force, the field applies a voltage to the wire and the wire attempts to destroy the field.

Obviously, however much the field was moving (consider the limiting case when the wave-length is very long), if its strength remained the same no useful result would be produced in the wire, but if the field varies from time to time, a varying electromotive force results in a varying current in the wire and, from this varying current, energy can be obtained in outside circuits.

A wire at right angles to this electrical field has no electromotive force induced in it.

For certain reasons these fields are usually made to vary with a simple harmonic motion, and the result on a conductor placed in the right direction is a simple harmonic electromotive force.

The resulting currents, and the phases of these currents in these conductors, depend on their electrical constants, which again depend partly upon their mechanical dimensions. If the conductor is fitted with inductance and capacity adjusted to be in resonance with the simple harmonic motion of the wave, the currents in the conductor will be in phase with the applied electromotive force.

If the inductive reactance is predominant, the current will lag. If the capacity reactance is predominant the current will lead relatively to the applied electromotive force.

If instead of considering the effect of the electrical field on the conductor we consider the effect of the magnetic field, that is, the number of magnetic lines cutting the conductor per second, producing a certain applied voltage, we are talking about the same thing, but sometimes this will give a clearer mental picture of what is happening.

Directional Reception.—If two similar conductors are chosen parallel to the electrical lines of the wave, but spaced along the direction of propagation, it is easy to see that the currents produced in them will differ in phase, and if we algebraically add these currents by means of some such arrangement as in Fig. 1 (page 109), we can produce new effects.

The single conductor we have been considering will have no knowledge of the direction of the wave motion because, from whatever the direction the wave is coming, the currents produced will have the same amplitude, provided the electrical force of the wave remains parallel to the conductor.

The currents in the two conductors, if added algebraically in a certain way, will, however, enable us to determine the actual direction of the wave, although we shall have still no knowledge of what is called the sense of that direction.

Suppose in Fig. 1 we actually subtract the two resultant currents by making the two conductors of electrically the same constants, and subtracting on a transformer T placed half-way between the two. Then we can easily see that a wave coming from the direction

* Paper read before the Institution of Electrical Engineers, January 14, 1920.

of the plane of the two conductors will not produce currents of the same phase, except in a few particular cases when the distance between the conductors is one, two, or more wave-lengths exactly, and consequently a resultant current will be left.

But if the direction of the wave is at right angles to the plane of the two conductors, the two currents, then being exactly in phase, will balance and no resultant current will occur.

Every other direction of wave will have a resultant current.

Fig. 2 gives the well-known polar diagram of reception on such a system. I have marked the two halves of this figure positive and negative for the following reason.

If the subtraction of the two currents is examined with regard to the phase of the resultant current, it will be seen that the phase remains the same throughout each circle, the current merely altering in amplitude, but the phase is completely reversed in the other circle.

Such a system as this, if we could arrange to shift the two conductors on a circle round an axis between them, would enable us, by plotting the curve of Fig. 2 for any wave, to determine the direction of that wave, and obviously, if we had somewhere a standard of phase, we could also get the sense of that direction by using the reversal of phase through the zeros.

In such a system as these two conductors, we are not limited to the simple subtraction of currents in the conductors. We can misphase our currents in the conductors and add them, or obtain the same final result in still other ways.

This system of two conductors would be very difficult to use in practice if the distance between them was great. Obviously to bring them nearer together will give a weaker resultant current, but this is actually done so as to enable the conductors to be easily moved on a common axis. To avoid the complication of transformers, other methods of addition or subtraction are used.

A simple bent conductor with resonance arrangements (Fig. 3) is one form of combined conductor suitable for direction finding. The conductors may, however, be joined at both top and bottom (Fig. 4) and the well-known frame aerial made up. Or a large number of conductors can be arranged in a circle with switching arrangements to switch to any opposite pair, or finally the well-known Bellini-Tosi method may be used to enable four conductors to be added together in such a way as to give the effect of a rotated pair.

Effect of Earth.—Before, however, describing this last method, I will introduce the question of the earth in directional reception.

If a straight copper wire A (Fig. 5) is pointed directly at a source of waves, and there are no other bodies near to distort the fields, no longitudinal currents will be induced in the wire except those of a second order, due to skin effects.

If another wire B is placed parallel to A, this also will have no currents induced in it. Neither of these wires will cut the magnetic lines.

But if a conductor S is placed between A and B at one end, the magnetic lines can now cut S, and the resultant difference of potential in S at its ends will induce in A and B an electromotive force which will result in currents in both A and B. If we replace the conductor S by a substance usually called an insulator, which has a greater dielectric capacity than ether, then if the dielectric current can be assumed to be made up of the displacement current in ether, plus elastic motion of electrons, currents will also be induced in A and B; but whereas in the case of a leaky dielectric or conductor the motion of the electrons is partly inelastic and the energy of the motion is partly lost, in the case of an imaginary perfect dielectric no energy will be lost in the dielectric.

Such a system it will be seen is not, however, directional; because, from any direction, the wave will induce the same electromotive force, but if we place another conductor at S′ the result, it is easy to see, is a directional receiving system similar to the frame of Fig. 4, because when the direction of the wave is at right angles to the plane of the wires A and B the electromotive forces induced in S and S′ are equal and opposite in their action on the conductors A and B, and other directions of wave give the diagram of reception represented in Fig. 2.

It is almost obvious that such a system can be replaced by a single horizontal wire above the surface of the earth, and even under the surface, depending on the conductivity and dielectric constants of the ground.

Of course, if one considers the final currents produced in such a circuit, their values will now be determined partly by the conductivity and dielectric constants of S and S′, and it is not immediately obvious what the values of such currents are.

An element of this earth effect undoubtedly occurs in reception even on frames, but it is probably minimised by keeping the frame away from the earth's surface as much as possible, and of course it will usually be approximately uniform in any direction.

Cosine Diagram.—Returning to the two vertical conductors or the frame-receiving aerial, it is now obvious that the electromotive force in such a system depends upon the angle which such a frame has to the direction of the wave. It can easily be shown that if the frame's dimensions are small compared with a wave-length, this electromotive force is proportional to $\cos \phi$ where ϕ is the angle of the plane of the frame to the direction of the wave (see Appendix 1).

Bellini-Tosi Aerials.—In practice the operation of a subtraction. Instead of rotating the frame, the rotation of the transmitter round the receiver gives the same effect; consequently we are enabled to determine the sense of the direction of a station.

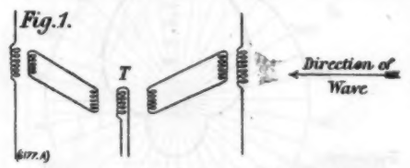
It will be seen that even if the phases of the frame and the vertical aerial are obtained correctly, unless the strength is obtained correctly also the zeros will not be opposite the maximum. Fig. 8 represents a series of diagrams obtained by the addition of various strengths of signals in the frame and the vertical aerial. These will be of interest in a later part of the paper dealing with instrumental errors. Some of these diagrams were obtained by Marconi on his original horizontal aerial experiments.

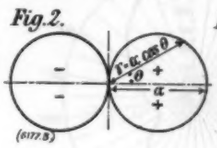
Practical Question of Taking Readings.—In practice such a process as plotting the cosine diagram from a station is impossible. Time is usually against one, and the question is introduced how, with some aerial arrangement such as described, can the direction of the wave be read?

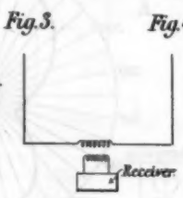
An examination of Fig. 2 shows that both maxima are very flat, that is, a large change of angle round these maxima gives a very small change of strength.

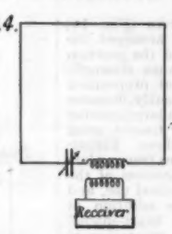
The zero of strength is extremely sharp, and theoretically if one determines directions by observing the position of this zero the best results should be obtained, but several limitations enter here.

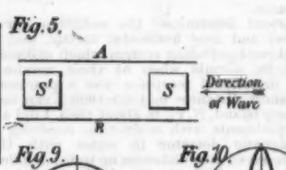
1. The signal zero extends over an angle owing to weakness.

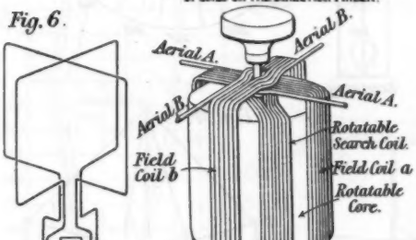


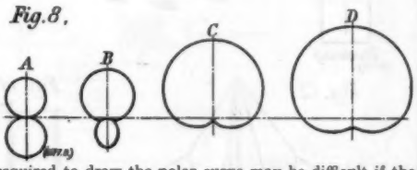












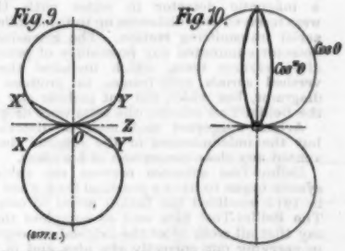


FIG. 9.—X Y and X Y′ represent the two positions of a rotating frame or a rotating search coil of a Bellini-Tosi set to give the two equal strengths O Y and O Y′ required by the operator to determine the direction O Z of the minimum of signals.

required to draw the polar curve may be difficult if the frame is fairly large—in other words the mechanical means for turning it will be cumbrous. So resource is had to a method of combining the effect of two frames placed with their planes at right angles to one another, the plane of each frame being vertical to the earth. This is done by connecting a piece of apparatus to the two frames so that in this piece of apparatus a miniature but concentrated duplicate is made of the original magnetic field of the wave, the only difference being that as now there is no electrical field, we are not actually dealing with a wave in motion. But if the electrical wave now shifts its direction through an angle ϕ the magnetic field will, in the subsidiary piece of apparatus, shift through ϕ degrees also. Consequently we can place in this miniature magnetic field a small frame an inch or so in size and determine the polar curves of various stations.

The simplest way of making this apparatus is to wind two coils at right angles as a miniature of the big aerial frame system, and to connect each of these two coils to an aerial. If we imagine each coil is placed parallel to the aerial frame to which it is connected, and the connections are the right way round, it will be seen that the miniature magnetic field is parallel to the main magnetic field of the wave.

Of course, there is no actual necessity to place the apparatus in this position, but, curiously enough, in the avoidance of certain errors, it has sometimes been found advisable to do so. This piece of apparatus invented by Bellini-Tosi is called a radiogoniometer. Fig. 6 shows two aerials and the coils to which they are connected, and Fig. 7 the two coils with the small rotatable frame.

Determination of Sense.—There is one other point that is of interest in direction-finding work, and that is the determination of the sense as well as the direction. I have noted that the two loops in Fig. 2 represent currents opposite in phase, and that any method of determining this difference of phase will give the sense. It is clear that, if a single straight conductor is erected at the centre of such a frame, the phase of the electromotive force in it will be independent of the direction of the signal. Therefore if we can combine the currents in this aerial and the frame so as to detect the phase change on the frame we can read off the sense.

I have noted in Appendix 1 that these two currents are 90 deg. out of phase, the vertical current representing the electrical field of the wave, and the frame representing the rate of change of the field, so that, to combine these currents so as to produce a zero of addition at any position, a misphasing operation has to be done on one aerial. For instance, the frame may be tuned and the vertical aerial left untuned.

Now if we obtain a zero reading from a signal in one direction by adding together the effects on the frame and vertical aerial, a rotation of the frame through 180 deg. gives a phase shift in the frame of 180 deg. As the phase in the vertical aerial is unaltered, we shall get an addition of the two aerial currents instead

2. As will be mentioned afterwards the actual zeros are very often indefinite.

3. Any jamming is, at this point, liable to interfere with the signal more than at points where the signals are strong.

For all purposes in the present state of wireless, I must assume that telephone reception will be used. The loss of the characteristics of a signal which any recording method necessitates is too great a loss to be balanced by almost any conceivable other advantage of recording, except possibly in very particular cases where a great strength is being dealt with, or wave-lengths are being used which are far away from the normal field.

Instead of reading the zero position an alternative is to read two positions of equal strength, and this is, and always has been, done in practice.

In ordinary frame or Bellini-Tosi practice, the operator swings his moving coil to two positions giving equal strength, and assumes the zero or maximum lies half-way between the two positions. Depending upon circumstances, he may swing through a narrow angle or a wide angle. It is a simple step from this to arrange two coils swinging together, with a changeover key to change from one coil to the other, so as to obtain again equality of strength.

This latter method which was tried out long before the war was again attempted with modern gear, but in practice, although possibly giving slightly more accuracy with untrained men, it was rejected because it was slower to use than the swinging by hand, and one always had to make sure whether the swinging was being done round a minimum or a maximum. Also the variable angle of swing was not easy to arrange while ensuring the accuracy of placing of the coils.

The Royal Air Force used this switch on aeroplanes, but instead of arranging two frames at the necessary angle, they took one frame and added to it a frame at right angles, connected first one way and then the other way. This is obviously the same thing. The angle between the equivalent frames is altered by altering the ratio of the sizes of the two Royal Air Force frames. I have not so far, even on aeroplanes, found the necessity of using switching arrangements, the operation being easily performed by hand swinging of the search coil, but possibly in the future it may be introduced on navigational stations when other sources of errors are eliminated.

I have mentioned that to read the maximum is not directly possible on account of its bluntness. It is rather interesting to speculate whether it is possible to obtain a sharp maximum.

One can only imagine the production of a real ray effect by covering with receivers a great area of wave front. But I can conceive of an apparently sharp

maximum being produced by some successive application of a power law to the original current, say by rectifying the original current through a square-law detector, reconverting this into high-frequency current, and rectifying again (Fig. 10); also by sliding back the potentiometer with a valve detector, and then amplifying afterwards. Exactly what would happen with such a scheme with jamming stations of different strengths is very doubtful, and one great advantage of the cosine diagram would be lost, for, with a real maximum system, it would be necessary to have an independent stand-by scheme with which to hear stations, but the cosine diagram is, with an occasional shift of the pointer, good enough as a stand-by.

HISTORICAL SKETCH OF WAR-TIME DEVELOPMENT.

It would probably start a controversy to go too closely into the original conception of directional reception. Fitzgerald, before Hertz, suggested frames for radiating, and probably, with his insight into things, noted possible directional properties. Hertz undoubtedly recognised directional properties in his receiving loop, but this was one which was not very well closed. All this was before Marconi's original work with vertically-polarised radiation.

In about 1899, 1900 and 1901, S. G. Brown and others suggested the use of spaced aerials for the purpose of obtaining non-circular radiation. The frame aerial was probably first suggested by Dr. Lee de Forest. In 1906 Braun combined aerials to give heart-shaped diagrams.

Marconi determined the radiation curves (Fig. 11) of bent and long horizontal aerials, and arranged the first direction-finding system which utilised the position given by signals when at their maximum strength. That directional reception was a practical proposition over short distances in 1905–1906 I can testify, because on Long Island, N.Y., in about 1905, I did a large number of experiments with multi-turn receiving frames using a magnetic detector in series with them. Signals were received over distances up to three miles from a plain aerial transmitting station. The insensitiveness of the detector eliminated any possibility of practical use, and after various tests, which included the addition of vertical aerials and frames to produce heart-shaped diagrams, but which did not include any conception of the Bellini-Tosi scheme, the tests were dropped.

Artom suggested and used a directional method, but the indefiniteness of the original description prevented any clear conception of his ideas.

Bellini-Tosi schemes revived the subject, and the system began to have a practical form when Major Prince, in 1912, modified the Bellini aerial to complete frames. The Bellini-Tosi idea was so complete that one might say that all work after the original conception consisted in carrying out correctly the idea and in the improvement of the receiving apparatus. The sensitiveness of the crystal, although greater than either the magnetic or electrolytic detectors, still limited the ranges of reception very greatly on directional aerials.

In 1913–14 I had in operation short-wave wireless telephone sets using three electrode valves for both transmission and reception. The development of simplified receiving circuits using these valves, utilising both high-frequency and low-frequency magnification, suggested the revival of the radiogoniometer for war purposes almost immediately after war broke out.

Early War Trials.—Early in September, 1914, possible uses of direction finding began to be evident to us, and we decided to try to improve the Bellini-Tosi arrangement so as to increase its accuracy and range. A Bellini-Tosi aerial system was erected on a 70-ft. field station mast at Broomfield. Standard Bellini-Tosi radiogoniometers were connected up to the receiving gear which was arranged to use either :—

1. Crystal only, or
2. Valve plus crystal.

I was very doubtful whether, when using the valve, reaction effects would not cause serious trouble, but fortunately this did not appear to be the case. Other troubles, however, did appear.

Owing to the short distance over which it was possible to receive signals on a frame when using only a crystal as a detector, none but the very strong stations could be received. It had been, therefore, usually impossible to obtain a large number of readings with which one could check the accuracy of the radiogoniometer. When starting work with the valve plus crystal, I found great divergence between the observed and true directions. In every case where it was possible to do so, directions were taken when using (1) crystal only, and (2) valve plus crystal. In each case the observed directions agreed, which pointed to the fact that the errors were probably not due to the valve. Finally, nearly all errors were put down to two causes :—

1. A coupling between the two aerial systems not due to the search coil. This gave maximum errors in the plane of either aerial.

2. Incorrect tuning and consequent mis-phasing of the two aerial systems. This gave maximum errors in the plane of 45 deg. between the two aerials.

The first difficulty was overcome by setting out the aerial systems accurately and by more accurate manufacture of the radiogoniometers. The second, by abolishing the double condenser, which pretended to tune the two aerials simultaneously, and by using two separate condensers. Tuning and phasing was done by means of a small buzzer transmitting radiogoniometer coupled to the aerial systems.

The correction of the first error, until quite recently, always gave us trouble, particularly with short waves. This was owing to the electric coupling between the two aerials. Incidentally the methods of checking that this coupling was zero were rather troublesome.

Another series of errors appeared afterwards, due to badly-constructed aerial tuning condensers, and to very puzzling dielectric losses. The condensers first used had ebonite as the dielectric, and any small difference in the internal losses was swamped by the large internal loss. Other dielectric losses, such as those in walls and tables, were not noticeable until later. This was when the aerials were made larger with respect to the wave-length, and the potentials at the ends of the aerials consequently became higher.

The introduction later of condensers having air as the dielectric gave trouble. This was owing to the type used being a built-up aluminium-vane condenser. It was found practically impossible to avoid resistance in the condenser, as the contact to the aluminium vanes could never be made perfectly good. We therefore reverted to brass vanes solidly soldered up, and after this all trouble vanished from a condenser resistance point of view.

Aerial Systems Used.—The first aerial systems were small diamond-shaped frames, supported on 70-ft. wooden masts (Fig. 12), the corners of the diamond being guyed out by ropes. A little later on, in the days when wood was still cheap, we erected four masts and put up square frames (Fig. 13). This seems to be the best form of aerial for general all-round accuracy. Still later, on account of the cost of masts, we reverted to the diamond-shaped frames with one high central mast and four small corner masts (Fig. 14).

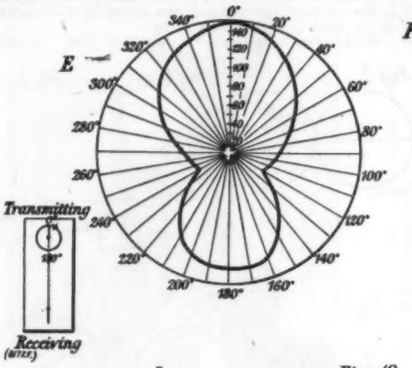


Fig. 11.

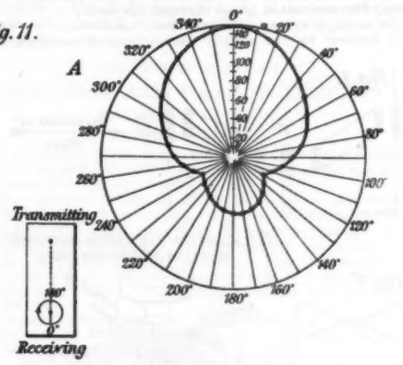


Fig. 12.

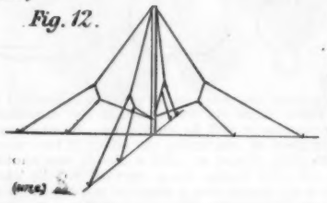


Fig. 13.

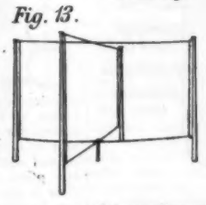


Fig. 14.

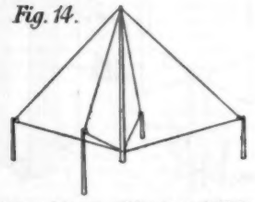
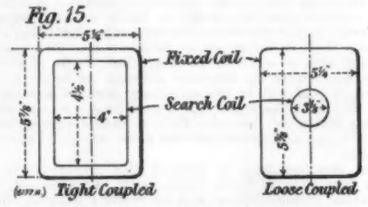


Fig. 15.



Multi-turn frames were seldom of any use in the Bellini-Tosi work; a condenser could always be inserted to tune up one-turn frames and, of course, direct connection with the aerials, as in rotating framework, is not required. Multi-turns, even if used in parallel to reduce inductance, have the disadvantage that the inductance varies in windy weather.

A few dimensions are appended of single-turn frames for the various wave-lengths chiefly used :—

Wave-length.	Shape.	Height.	Diameter.
		ft.	ft.
200 m. to 400 m. ..	Diamond ..	50	50
400 m. to 800 m. ..	(1) Square ..	60	60
	(2) Diamond ..	90	90
800 m. upwards ..	(1) Square ..	120	120
	(2) Diamond ..	170	170

Any larger sizes than these became difficult to handle, owing to the self-capacity of the frame becoming large compared with that of the tuning condenser. Actually with modern amplifiers these frames give all that can be required in the way of signals.

Insulation and Leading-in.—Insulation is not an important function because, in wet weather, all insulators get wet about equally and the effect on the two aerials is about the same. At the same time it is preferable to avoid any chance of inequality by using long lengths of porcelain at all suspension points.

The leading-in of aerials is a very troublesome process. The lead-in wires from the central mast have to be firmly fixed with regard to one another, and yet if they are supported rigidly from the mast to the building the latter becomes very noisy, due to the mast vibration being transmitted to the walls of the building. Insulation at this point is more difficult to maintain than elsewhere and is more important, as the building is liable to shield one set of aerial insulators more than the other.

The buildings were usually placed in an angle between the legs of the two aerials, and this resulted in a capacity coupling between the aerials which was negatived by a small condenser connected across one of the legs of one aerial and the opposite leg of the other aerial.

Radiogoniometers.—During the war we made practically no alterations in the dimensions of the radiogoniometer coils designed by Bellini, except in the number of turns on the windings, for as originally designed they produce a very small error, and to have eliminated this error would have taken a great deal of work, which was not necessary in view of more serious errors.

Two dimensions of coils which we used for different circumstances are shown (Fig. 15), viz. :—

(*a*) Which we called "tight coupled," and
(*b*) Which we called "loose coupled."

Actually both types were tight coupled, for in each case the coupling when at a maximum with one aerial alone was more than that required for maximum signals, if aerial and search coil were tuned to the same wave-length.

Almost at once we discovered that in war the enemy does not send on one wave-length only, nor does he send V's when requested, and many were the schemes evolved both for tuning to his wave-length and for taking his direction rapidly, say, all in the space of a few seconds. The difficulty was enormously increased by the extreme care with which the aerials had to be balanced. After a little experience we found that if the aerials were tuned to, say, 800 m., and carefully balanced or phased, then by re-tuning the intermediate and final circuits, but without altering the aerial tuning, signals could be received with only a slight falling-off in strength, from 200 m. below to 200 m. above this tune, that is from 600 m. to 1,000 m. This was due to the above-mentioned tight coupling of the radiogoniometer.

Some attempt was made to use Mr. Russell Clarke's scheme of linked condensers. This scheme was, however, not extensively tried; for the reaction coil had to be readjusted continuously in order to keep the set near the oscillating point, and it was found that if the final jigger coils were made of sufficient length, they also worked over a big range without a condenser in parallel with them. With only the reaction coil and intermediate condenser to handle, operators became very expert at searching over considerable ranges of wave-length. They rapidly found out the German rule for change of wave-length, and the various wireless signals which indicated these changes.

Later on, with modern amplifiers, all these things became easy, but in the early days they caused much trouble. After the German rules for wave-length changing had been determined, quick searching only became necessary when these rules were being changed, and also in a few other cases.

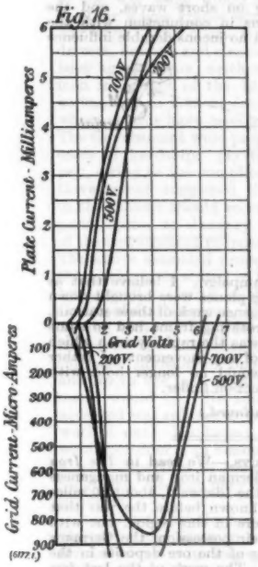
First Valves and Circuits.—Aside from the above-mentioned errors, other errors were not at first serious. I had modified Franklin's reaction circuits for spark reception to give simpler tuning arrangements, and these circuits, when added to the Bellini-Tosi system corrected as above, made a very good direction finder, which at that time was of extraordinary sensitiveness. It was probably fortunate in the first year of our work that we used the soft valves, because no hard valve has been constructed which can compare with these "O" type tubes as high-frequency magnifiers. They necessitated, however, trained men in their manufacture, and trained operators for their efficient use.

I give here a characteristic of a "C" valve for those

who care to compare it with that of a modern hard tube. If the "C" valve characteristic (Fig. 16) is compared with that of a hard tube, the comparison will show that the "C" valve is equal in magnifying power either to 16 hard French tubes in parallel, or to three in cascade. Actually in practice, when used by a skilled operator, it is better than three in cascade in an amplifier having aperiodic intervalve connections. Some of the apparent amplification shown by the characteristic is actually not obtainable because, on account of grid conductivity, a rather large ratio of capacity, to inductance is required in the grid tuning circuit. The use of this large ratio of capacity to inductance in the direction-finding receiving gear accidentally avoided for us the serious error known as "vertical," which was afterwards obtained with hard tubes, and it was very fortunate, for we had quite enough other trouble to contend with at the time. With the "C" valve the average high-frequency magnification when using reaction was about 150. With high-frequency magnification the receiving power of the frame and Bellini-Tosi system at once became almost equal in value to that of the vertical aerial.

If an aerial system is taken and high-frequency amplifiers attached to it, a practical limit of amplification

Fig. 16.



is reached when jamming and X's become too strong. In practice, therefore, it is possible to amplify up frame signals to a strength even greater than those of a vertical aerial, for owing to the frame's localised receptive diagram there is liable to be less interference.

Fig. 17 gives a diagram of one of the first circuits in use. Captain Tremellen was very fond of the ingenious double-magnification circuit (Fig. 18), due to Schlomilch, as was also the original high-frequency magnification without reaction. I usually preferred a single low-frequency amplification after the crystal.

I have mentioned that the production of valves at that time required special men. Even then it was a terrible process. Again and again we lost the knack of making good tubes, owing to some slight change in the materials used in their manufacture. A thorough investigation was impossible, as all hands were out on the stations. On several occasions we were down to our last dozen tubes.

This type of tube had been tested out on long waves at Clifden for quite long runs, and on those circuits they were very steady. The shorter waves, however, necessitated higher values of filament current and lower values of vacua, thereby shortening the steady life considerably. It is, however, pleasant to record that "Methusalah" was removed after 8,500 hours, only to make room for a new circuit with hard valves, and this to the regret of the operators. A good many examples were obtained of lives nearly as long as this.

Everything suggests that a long ageing is necessary to produce a steady valve, unless success is obtainable with a gas such as helium or neon. Curiously enough, a spectrum analysis of an old tube never showed anything but hydrogen, but with hydrogen I was never able to make a tube that was any good. A few tubes were obtained which, after 1,000 hours, would run indefinitely as amplifiers or oscillators without any filament battery. The filament was apparently being heated by the high-tension battery, which was usually 400 volts.

Great credit is due during this period to Messrs. Edison and Swan, Limited, and particularly to Mr. Copelin and his staff, for the patience with which they carried out my instructions for making the valves.

Another Source of Error.—Quite early in 1915 another error appeared which we nicknamed "Vertical." This error was only small, and save for the determination of its cause need not have been regarded. We noticed that the two zeros shown in Fig. 2 were seldom opposite to one another, even if using only one aerial of the Bellini-Tosi system. This was traced to a small "vertical aerial" receptive power, chiefly due to the difference in the capacity of the grid of the valve to earth, and of its battery to earth. We corrected it at first by adding a small condenser from the grid to earth, the value of the capacity being equal to that of the battery to earth. Owing to the smallness of the error, however, this correction was not often applied.

I can probably explain the meaning of the error by taking the simple case of a frame directly connected to a valve (Fig. 19). Such a frame as shown, if not connected to the receiver, gets current induced in it which gives a potential difference between the terminals A and D of the condenser. This potential difference is the correct cosine function of the direction. If now a valve grid G (Fig. 19a), is connected to D, and the valve-filament battery, B, to A, the capacity of G is usually small compared with B, and, besides the true directional reception of the frame, there is a reception due to these capacities to earth. I have redrawn this arrangement in Fig. 19b, which shows the action of the wave in alternating-current form. Fig. 19c shows the arrangement in bridge form. From this it will be seen that unless the capacity C is equal to the capacity H, a current will flow through the condenser A D. The fact that a current flows through the condenser A D means that there is potential difference across the

Fig. 17.

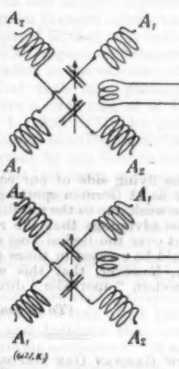


Fig. 18

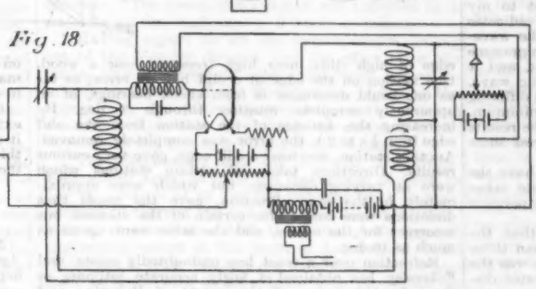


Fig. 19.

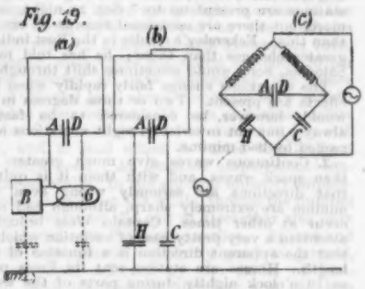


Fig. 20.

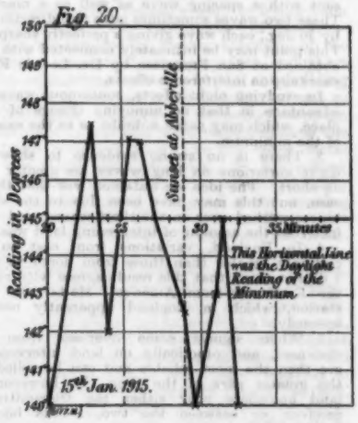
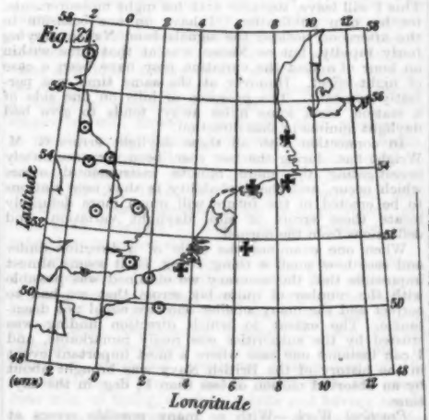

Reading in Degrees
Sunset at Abbeville
35 Minutes
This Horizontal Line was the Daylight Reading of the Minimum.
15th Jan. 1915.

Fig. 21.



terminals A and D, which is independent of the directional properties of the frame. The result of this circular reception on top of the directional reception is a "cottage loaf" shaped diagram of reception, the minima of which are not opposite to one another. This point has already been brought out and illustrated in Fig. 8.

With the use of hard valves, and the consequent high insulation of grids, these "vertical" troubles increased a great deal, and they increased still more when the "aperiodic" aerial was brought into use. Methods other than the addition of condensers to the grid were afterwards used, for they were more reliable as they required no adjustment. They were chiefly methods of shielding and shunting to earth and will be mentioned later.

Night Errors.—So far, I have only touched upon the aerial and upon instrumental difficulties and errors. Probably, it has occurred to some, working on signal strength, that the extraordinary variation of signals at night, so different from the constancy during the day, might be accompanied by variations in apparent direction. I must confess that I had not thought seriously about it.

In December, 1914, we erected in France, at Blendecques, near St. Omer, and at Abbeville, the first two war direction-finding stations, these making the first position-finding group erected by us during the war. Blendecques, unfortunately, had a fixed daylight error which puzzled us, and not until Abbeville was constructed did Captain Tremellen note that night directions did not maintain the constancy of day readings. The first station concerning which he noticed this effect was KAV, the old German press station, and I am able to show here a copy of his original curve taken of KAV's movements during a sunset period (Fig. 20).

This curve is typical of a sunset movement, but I still cannot say whether any such apparent irregularity exists as a general thing, and certainly we were never able to arrive at any system of correcting bearings by using the idea of regularity.

After this first indication we, of course, noticed that night variation was a general thing, and it remained throughout the war a serious defect in the direction-finding work. I have attempted to set down here a number of facts regarding night effects which may be useful to those building up theories, but I must apologise for the scarcity of real material.

One must remember that all stations were concentrated on a military and naval object, i.e., Intelligence work, that the stations being watched sent erratically, and seldom at the right time or for a sufficient length of time to make observations worth while, and also that the stations were worked by men not particularly interested in direction-finding as a research. Only long-wave Press stations sent for lengthy periods, and we could not afford to concentrate direction-finding men on watching these stations. However, Captain Tremellen and Lieutenant Adcock, in France, among others, and particularly Lieutenant Eckersley in Egypt and Salonica, succeeded in obtaining valuable information, the latter in conjunction with experiments developing the theoretical side. Eckersley is, I believe, preparing to publish his work on direction-finding. The work of these men suggests possible improvements in apparatus which will eliminate a great deal of the night trouble.

We were not the only people suffering from night effects. As is well known, the German Navy directed their Zeppelin fleets by direction-finding from land stations. They also used a method of intercommunication between the land stations by wireless telegraphy. I am permitted to show approximately the positions of the German direction-finding stations and also the approximate position of some of our own stations (Fig. 21). The Germans, in raids on England, suffered from a bad base-line, and this, in combination with night effects, made their directional apparatus useless on many occasions.

An interesting point regarding the night effects was discovered later by Captain Tremellen. The Germans had two radio-phare stations for enabling their Fleet and submarines to determine their positions in the North Sea without having to transmit. These radio-phares in effect consisted of a rotating frame continually sending during rotation. A signal was sent to give the zero of time, and any ship noting the time interval between this zero and the zero of signals could then determine its angular position from the station.

The fact that a frame transmits vertically as well as horizontally, and that at different points in its rotation the vertical radiation is polarised in a different direction, should lead one to expect curious results at night. Owing to the continuous rotation of the transmitting frame, very strong signals were necessary to take quick

bearings at a direction-finding station. Notwithstanding the difficulty, Captain Tremellen was able to note a large variation of the apparent direction of these stations at night as the frame rotated. This was done by reading the minimum on his own radiogoniometer, and not by noting the minimum of signals with his search-coil stationary. Unfortunately these stations have stopped work, otherwise a complete investigation of this would have been undertaken.

NOTES ON NIGHT EFFECTS.

1. Large swing readings are better than minimum readings. To obtain readings of the actual minima at night is very difficult, for from spark stations with no definite zero one gets peculiar changes of note, and different operators will estimate the weakest place at quite different angles. I have attempted to draw in Fig. 22 a representation of a typical night minimum. This effect is sometimes very marked from Telefunken stations. Even with a swing reading, a very distinct difference of note will often be obtained at the positions A and B, the note on the one side having obviously fewer harmonics, i.e., being duller in sound, than the note on the other side. This again adds to the difficulty, and the reason for the effect is not at all obvious. In England and France, errors on swing readings on spark stations are present up to 7 deg. at night, and seldom more, but there are occasional records of errors greater than this. Eckersley's results in the East indicate much greater changes than these; he has told me that at Salonica, Sofia would sometimes shift through 90 deg.

The directions change fairly rapidly when bad night effects are present. Two or three degrees in a minute would, however, be considered to be fast. Nearly always, but not invariably, night variations are accompanied by bad minima.

2. Continuous waves give much greater variations than spark waves, and with them it is quite definite that directions are seriously wrong even when the minima are extremely sharp, although bad minima do occur at other times. Captain West brought to my attention a very pretty case of variation which indicates that the apparent direction is a function of the wave-length. Horsea arc station sent its Press programme at 10 o'clock nightly during parts of the war, and it sent with a spacing wave as well as a marking wave. These two waves sometimes gave two directions differing by 30 deg., each wave giving a perfectly sharp minimum. This point may be intimately connected with the results obtained at San Francisco by Dr. Lee de Forest some years ago on interference effects.

In studying night effects, continuous waves have the advantage in that no annoying change of note takes place, which may cause a doubt as to the exact position of the minimum.

3. There is no strong evidence to show that the night variations on long waves are greater than those on short. The idea we obtained was that this was the case, but this may have been due to the shorter distances worked over on the short waves, and also to the fact that the amount of intervening land was smaller.

4. In England, variations from east to west are certainly greater than those from north to south, but I do not think that this result agrees with results from the East and from America. Malta was a peculiar station, which in England apparently never varied seriously.

5. When signals come over-sea from moderate distances, and practically no land intervenes, results are then the most reliable and can be relied upon for the greater part of the time. If, however, there is land anywhere near either the transmitter or the receiver, or between the two, results become very troublesome.

The minimum distance at which night effects have been noticed in England or France is about 15 miles.

Captain Tremellen noticed quite early, that when two transmitting stations with differently shaped aerials were side by side, the directions obtained at night by a Bellini-Tosi station were different.

Mountainous country between stations seems to give the very worst night effects, and I should think that extremely wooded country would also be bad, but I have no evidence of this.

Theories of Night Effects.—In the early days I had vaguely in my mind ideas of refraction and reflection in the lower and upper layers of the atmosphere which thereby produce twisting of the wave front. I had also the idea of rotating fields which thereby destroy the minimum. Eckersley's theoretical and experimental work with night effects in the East, and with aeroplanes—also, quite independently, Adcock's work in France on aeroplanes—gave a clue to a part of the trouble at least. These two engineers have both suggested apparatus which should, when developed, improve our work at night. I will give a very rough sketch of this important work, leaving it for them to give exact accounts of their work at another time.

It was noticed that when Zeppelins were well at sea, night errors were not usually serious, but aeroplanes nearly always gave trouble. Experiments were carried out during the day with an aeroplane flying at varying heights, and at different angles to the radius from the receiving station. To see clearly what happens in this case, firstly it must be remembered that the aeroplane, being small and having the aerial flying out backwards, does not usually radiate a wave in which the electrical lines are predominantly vertical and the magnetic lines horizontal. If this vertically-polarised radiation only were present, a receiving loop at a distance would receive no signals when its plane was at right angles to the direction of the aeroplane. If, however, the aeroplane is at a height and some of the magnetic field of the wave reaches the loop in such a manner that it is partly vertical in one plane and with the lines leaning forward towards the receiver in the other plane (Fig. 23), a current will be induced in the loop, and the resultant zero position, if the frame is rotated, will be produced by the sum of the two currents due to this effect and that of the vertically-polarised wave. It is very noticeable that the error produced becomes negative instead of positive if the aeroplane reverses its direction. A horizontal loop will receive from an aeroplane flying at a height, on account of this twisted field. An aeroplane flying towards or away from a station gives no error.

All the above were daylight results, but it was suggested by Eckersley that this aeroplane effect was produced at night by the reflection from irregularities in the Heaviside layer, and there is good evidence that this theory is true.

Again, a horizontal loop receives during night variations, and Eckersley has proved experimentally that the strength on the horizontal loop and the night variation agree with the theory in a remarkable way.

In the later stages of the war, night errors from Gothas were extremely troublesome, the only satisfactory times being when they were flying either towards or, preferably, away from the observer.

DAYLIGHT ERRORS.

Daylight errors, aside from instrumental ones, were much more difficult to notice. They were seldom as much as the possible errors of the instruments.

Apparently it is a bad thing to place stations on the edge of high cliffs, near high trees, or near a wood. One station on the edge of a cliff had an error, as far as one could determine it from check bearings, of an apparently complete rotation through 3 deg. By increasing the distance of the station from the cliff edge from $\frac{1}{4}\lambda$ to 2λ, the error was completely removed. Another station, also near a cliff edge, gave very curious results. Directions taken of certain stations which were at varying distances, but which were approximately in the same direction, gave the result that directions were correct for certain of the stations but incorrect for the others, and the error went up to as much as 10 deg.

Fig. 22.

Fig. 23.

Refraction over a coast line undoubtedly exists, and Eckersley has obtained a fairly accurate estimate of the refractive index of the coasts of Palestine and Cyprus, this being checked by a large number of stations. This I will leave, together with his night measurements, for his own publication. I have on one occasion in the afternoon noticed the signals from Nauen varying fairly rapidly, but as Nauen was at that time within an hour of sunset the variation may have been a case of night effect. Hanover at the same time was perfectly constant. The presence of hills on one side of a station, even some miles away, tends to give bad daylight minima in that direction.

In connection with all these daylight errors G. M. Wright has, during the last year, been very accurately investigating the more minute instrumental errors which occur, and the probability is that new stations to be erected in the future will much more definitely locate these errors of site, daylight variation, and deflections from the normal.

When one examines the scale of a direction finder and sees how small a thing 1 deg. is, it seems almost impossible that the accuracy we obtained was possible with the number of quite big errors that we had to correct and the many smaller ones we could not disentangle. The extent to which direction finding was trusted by the authorities was really remarkable, and I can instance one case where a most important event in the history of the British Navy was brought about by an observed motion of less than $1\frac{1}{2}$ deg. in the daytime.

Practical Work.—With so many possible errors at night, it was never safe to use only two groups, in fact one gained a false confidence in the beautiful intersections made by using only two stations and only had occasional shocks when the German fleet was found to be well inland. A third station enabled one to know much more definitely if results were of value, and I personally preferred four, the last one being a check on the other three.

A system of good rapid land-line communication to a centre was very essential, and our Post Office in England and the Army authorities in France did magnificent work in this direction.

Besides these groups of stations, many single stations were erected, particularly for submarine work, and very valuable results were obtained. The German submarines were fitted with powerful spark stations working on 400 m., and I very much doubt whether a signal was ever made by one without our stations recording the position. Of course, it does not mean that in a large area such as the Western Atlantic, if we know the position of a submarine we can sink her, but if we do know her position we need not send our convoys near to her.

In the Mediterranean, which was a great hunting ground for submarines, our direction-finding stations were forced to use a system of wireless intercommunication, and I have heard the story that one Austrian submarine requiring her position, came to the surface, sent signals, waited for us to give her position, and then thanked us and again submerged. This is only to indicate the danger of linking up direction-finding stations by wireless telegraphy.

Short-wave Work on Rotating Frames.—The Bellini-Tosi system is undoubtedly the most rapid and accurate method of taking directions, but many troubles were experienced when we began to need short-wave direction finders. This was in days before the cascade amplifier came into its own. For short-wave reception under 300 m. it was necessary to use rather large rotating frames, and only just as the war was finishing were we able to tackle waves under 200 m. satisfactorily on the Bellini-Tosi system. The mass of a frame will always be against the use of the latter for good work because, although ultimately there is no real difference between a rotating frame and a Bellini-Tosi in accuracy in clear places, the ability to take an extremely rapid reading makes the Bellini-Tosi infinitely preferable.

With a frame, the balancing troubles do not occur, but the "vertical" error is just as bad and requires just as careful attention. In consequence of the balancing trouble on short waves, Colonel Blandy erected a large number of frames for direction-finding German aeroplanes which were working on short waves, and the work done by these stations in conjunction with the Flying Corps, must have had no inconsiderable influence on the flying side of our campaign. I believe that as many as 11 German spotting-planes were brought down in one week due to the intelligence work of these stations.

One advantage that the rotating frame had to some extent over the Bellini-Tosi was the rapidity with which it could be erected in times of any movement. I rather think, however, that this would no longer hold with the modern "aperiodic" direction finder.

(To be continued.)

NEW GERMAN ORE DEPOSITS.—We read in *The Iron Age*, New York, that new German iron and manganese deposits have been found in the Idarwald, about 30 miles south of Coblentz. It was known before the war that there were deposits of iron ore in this region, but with the Lorraine ironfields in their possession, the Germans did not consider the working of the ore deposits in the Idarwald profitable enough. The work of the last few months, however, has given very satisfactory results, and it appears that the whole of the Idarwald contains rich ore beds. Deposits have been met in the regions of Rhaunen-Sulzbach, Weitersbach and Horbruch, 12 miles from Berncastel. The ore is at a depth of 6 ft. to 10 ft., but in several places, just below the surface. It is said to contain from 55 per cent. to 60 per cent. of iron and up to 30 per cent. of manganese.

PROPERTIES OF COLD-ROLLED METALS.—The results of some tests of cold-rolled metals and alloys were tabulated, by Dr. Ing. Pomp, in the *Zeitschrift des Vereines Deutscher Ingenieure*, of November 1 last. The specimens were supplied in bars of 10 mm. by 4 mm. cross-section, and were rolled down to thicknesses of 3·5, 3, 2·5, 2 millimetres, the reduction in thickness amounting to 0·5 mm. in each operation. The specimens were submitted to tensile strength and elongation tests, and further to Brinell hardness tests; in the latter case a ball of 4 mm. diameter was used and the load applied within 20 seconds. The copper examined, a metal of good commercial purity, increased in strength by 79 per cent. maximum (for the 2-mm. thickness) as the thickness was reduced, first rapidly, then more slowly; the hardness curve was of similar shape, but the increase in hardness was more marked, 133 per cent. max. The elongation diminished, soon attaining a fairly constant value. The zinc specimens tested were very little affected by the cold-rolling. A zinc-aluminium alloy, containing 3·5 per cent. of aluminium, did not show any material change either in strength or in hardness; but the elongation decreased markedly as soon as the thickness was reduced more than 1 mm. The specimens of electrolytic iron behaved much like the copper specimens; the maximum values attained, increases in strength of 69 per cent. and in hardness of 115 per cent., were, however, lower than in the case of copper. The mild steel examined also resembled copper in its behaviour, but the maximum increases, 88 per cent. in strength and 156 per cent. in hardness, were slightly larger than those observed with copper; the elongation diminished, rapidly at first, then more slowly. The composition of this mild steel was: 0·03 per cent. of carbon, 0·29 per cent. of manganese, 0·01 per cent. of silicon, 0·019 per cent. of phosphorus, and 0·025 per cent. of sulphur. An analysis of the electrolytic iron is not given; there is a reference to the copper bands of shells, however, and the iron was probably produced by the electrolysis of ferrous chloride, which was practised on a large scale during the war in Germany for the purpose of obtaining an iron which might serve as a substitute for copper.

INDUSTRIAL NOTES.

As announced in our last issue, a settlement in the railway dispute was arrived at on the 15th inst. The men's demands were, briefly, the following: (1) That the scheme should be based on the highest pre-war rate in each grade and not on the average. (2) That there be no sliding scale based on the cost of living. (3) That anomalies and individual hardships be removed from the scheme; further, that all grades be included in the new wages proposal. (4) Retrospective pay, from August 18, 1919, of any increase resulting from the scheme. (5) The Irish railwaymen to be included in the settlement. In reply to these points, the Government stated that: (1) The principle of averages was to be maintained as a basis and (2) the sliding scale based on the cost of living also. (3) The new wage increase of 5*s.* would be extended to all grades now receiving the war wage of 20*s.* 6*d.* (women) and 33*s.* (men); an increase of 2*s.* 6*d.* would be made to boys and girls under 18 years of age. An increase in the war wage would also be given to operatives in other wages grades who do not yet receive the full war wage. This clause is not applicable to locomotive drivers, firemen and cleaners, whose rates have already been agreed upon, neither to the clerical staff, nor to men in receipt of the 12½ per cent. or 7½ per cent. bonus, nor to men in docks and marine departments, where awards have been given through other channels. The Government were prepared to deal with individual cases of hardship. (4) With regard to retrospective pay, owing to the complication in the calculations, the Government suggested that each man participating in the scheme should receive a fixed sum of 1*l.* for the period prior to January 1, 1920. (5) The principle of the Government proposals to be extended to Ireland. The above amended proposals by the Government are those which, as stated in our last issue, were accepted by a small majority of the delegates of the National Union of Railwaymen, at their conference last week. At the close of this, Mr. J. H. Thomas, M.P., said it was no use disguising the fact that there was considerable division of opinion amongst the delegates, and up to the last moment it was doubtful what the result would be. He added that the settlement now accepted was subject to various details which had to be worked out. He hoped and believed that the men would consider it an honourable settlement. It marked a new departure in industrial questions and, in his judgment, was the only way of meeting an abnormal situation.

It is stated that the Associated Society of Locomotive Engineers and Firemen will soon put forward a claim for an advance in wages owing to increased cost of living. The signalmen and other grades not included in the settlement with the National Union of Railwaymen are said to be also desirous of opening up negotiations for an advance. The Railway Clerks' Association state that an agreement was reached between them and the Railway Executive Committee on August 26 last, but up to the present no effect had been given to it.

Last Friday, Sir Hugh Bell, Bart., delivered an address before the Manchester Chamber of Commerce, on "The Railways and the State." He said that the railway property of this country represented an expenditure of over 1,300,000,000*l.* Before the War altered the calculations, they had gross receipts amounting to 139,000,000*l.*, and a surplus of 50,000,000*l.* They afforded employment to over 600,000 persons, so that each person employed represented about 2,200*l.* of capital. In the coal trade or the steel trade, barely one-tenth as much was needed to set a man to work, which showed the dependence of the railways on an adequate supply of capital. It followed that a much greater proportion of the gross revenue was needed to provide interest on that capital. Such a business as the railways, representing so great a proportion of the total business of the country, could not be allowed to become parasitic and dependent on help from without. It had to be a healthy commercial enterprise which out of its own resources found all that was required for its maintenance. He added that if he had to choose between nationalisation and private ownership of the railways, he would make the choice without hesitation. No price offered by the State would tempt him. He did not believe the State would be able to pay the price which the railways were really worth. If less were paid, they would be by so much defrauded. If more were paid, the railways would become a drag on the revenues of the State. To place the administration of property of such magnitude and of such vital importance to the community under Government control was to run risks of a kind no prudent man would accept. Let the railways, he concluded, be returned to the present proprietors, who must be relieved of the fetters which now tie their hands and prevent them from managing their property in the best way.

Mr. J. T. Brownlie, chairman of the Amalgamated Society of Engineers read a paper on "The Workers' Interest in Output," at a national conference of working-class associations held at the Memorial Hall, Farringdon-street, London, last Saturday. One of his statements was to the following effect: "The workers had a right to see some signs of a definite and reasonable attempt on the part of the Government to grapple with the unemployment problem." Now, on page 817 of our issue for December 19 last, we reproduced the explanation given by the Minister of Labour with regard to the Training Grant Scheme in the engineering trades; this explanation, by reason of the action taken by the trade unions, reads throughout as an apology. The scheme deals with the training of ex service men, and the Minister's explanation contains the following: "... As regards the number of trainees, it is suggested that *this should not exceed* 1,750; *which is less than one-third per cent. of the total membership of the engineering trade unions.* As a further safeguard, *the number of trainees in any one factory would not exceed* 1 *per cent. of the total number of employees in the works.* ..." (The italics are ours.) Does Mr. Brownlie desire the Minister of Labour to increase the ridiculously low proportions of one-third and 1 per cent. referred to?

The strike situation was discussed at the morning conference of the ironfounders held in Manchester on the 15th inst., but nothing definite was decided. At the afternoon session the conference debated a resolution to resume work. It was ultimately decided to take another ballot. A special committee was appointed consisting of 12 members representing the branch delegates, and the three committees in equal numbers. The committee's report was accepted by a majority at the conference; it reads as follows:—

"Having regard to all the circumstances arising out of the foundry dispute, and the effect upon the trades union movement, this conference agrees to submit to a ballot of the three unions, including the apprentices, the following proposals, with a strong recommendation that they should be accepted in the interests of the unions involved in the dispute:

"The Engineering and the National Employers' Federations agree as from the resumption of work to pay an advance of 5*s.* per full ordinary week to male workers 18 years of age and over, members of the three unions, in accordance with the terms of the general engineering award of the Court of Arbitration, dated November 5, 1919. Future general alterations in wages shall be dealt with in accordance with provisions for avoiding disputes to be mutually agreed upon.

"The resumption of work shall take place by January 26, 1920. It may be possible, by reason of special conditions, to arrange, after the acceptance of these proposals, for an earlier resumption. In such cases individual arrangements will be made. It must be recognised that it will not be possible to secure a complete resumption by the date named. The employers will, however, re-employ their workpeople as rapidly as the foundry circumstances will permit, and new workers will not be taken on so long as those workers who were in the same employment before September 20, 1919, are available, provided such workers present themselves for re-employment not later than February 2, 1920. No victimisation shall take place on either side.

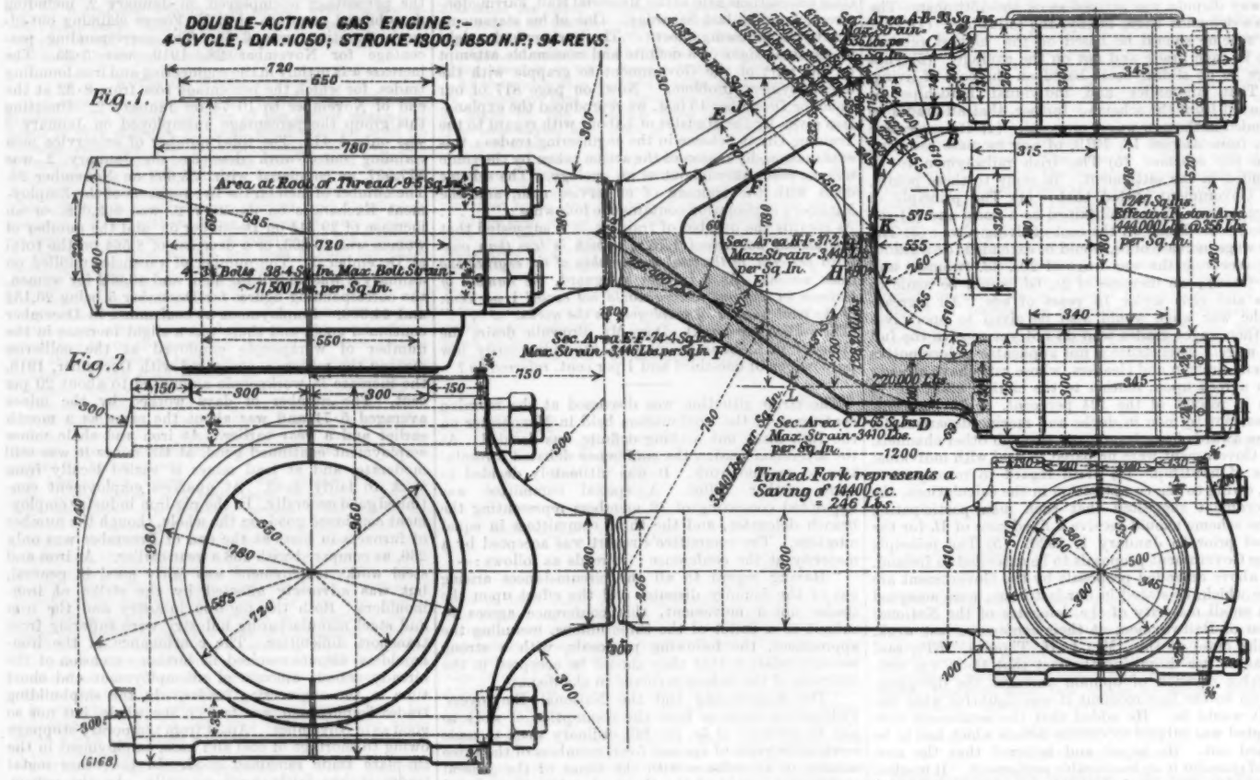
"Provided that resumption takes place as above, a conference, in accordance with the employers' previous proposals, shall be held between the Federations and the Executives of the three trade unions in the week commencing February 2, 1920, for the purpose of discussing the working conditions in foundries, including questions arising out of the introduction of the 47 hours' week with the view, *inter alia*, of fixing, on their merits and having regard to any special arguments, minimum standard rates for the various districts; and including also the questions of the jurisdiction of the unions over apprentices and the rates of remuneration of apprentices."

At the time of writing the ballot is taking place.

The prolonged strike in the iron foundries, says *The Labour Gazette*, caused a large and increasing amount of unemployment and short time in the engineering trades in December. At iron and steel works and in some other metal trades employment was also affected by the moulders' dispute, but was fairly good in general. In the shipbuilding trades employment was only fair. In most other trades it was good or fairly good, and on the whole was about the same as in November. The general level of retail prices of food and other items (including rent) of working-class family expenditure at January 1 was approximately 125 per cent. above the pre-war level. Trade unions with a net membership of 1,500,630 reported 3·2 per cent. of their members as unemployed at the end of December, as compared with 2·9 per cent. a month earlier—the increase being due to unemployment in the engineering and shipbuilding trades—and 1·2 per cent. at the end of December, 1918. In industries in which workpeople are insured against unemployment under the National Insurance Acts, the percentage unemployed on January 2, including demobilised members of H.M. Forces claiming out-of-work donation, was 6·58. The corresponding percentage for November 28, 1919, was 5·35. The increase was mainly in the engineering and iron founding trades, for which the percentage rose from 8·32 at the end of November to 10·74 on January 2. Omitting this group the percentage unemployed on January 2 was only 4·41. The total number of ex-service men claiming out-of-work donation on January 2 was 377,957, as compared with 353,668 on November 28. The number of men on the live registers of the Employment Exchanges on January 2, was 503,658, or an increase of 29,344 on December 5; and the number of women was 46,863, or a decrease of 8,564 on the total at December 5. The number of vacancies unfilled on January 2 was 25,979 for men, and 46,002 for women, the corresponding figures for December 5 being 26,152 and 44,300. Employment at coal mines in December continued good, and there was a slight increase in the number of workpeople employed at the collieries making the returns; compared with December, 1918, the increase in workpeople amounted to about 20 per cent. The number of days worked by the mines averaged 5·71 and was about the same as a month earlier and a year earlier. At iron and shale mines employment continued good, at tin mines it was still moderate, and at lead mines it varied locally from slack to fairly good. At quarries employment continued good generally. In the pig-iron industry employment continued good, on the whole, though the number of furnaces in blast at the end of December was only 236, as compared with 268 a year earlier. At iron and steel works employment was fairly good in general, but was adversely affected by the strike of iron-moulders. Both the pig-iron industry and the iron and steel manufacturing industry were suffering from transport difficulties. The continuance of the iron-moulders' dispute resulted in further extension of the already serious amount of unemployment and short time in the engineering trades. In the shipbuilding trades employment was fair on the whole, but not so good as in November. Apart from temporary stoppage owing to shortage of coal and bars, employment in the tin-plate trade remained good. In the other metal trades it was fairly good generally. In the cotton trade employment during December continued fairly good in the spinning section and good in the weaving section. Employment in the building trade was not quite so good in December as in November, but bricklayers and carpenters continued well employed. In the woodworking and furnishing, brick, cement, pottery and glass, paper and printing, and food preparation trades employment remained good generally. Skilled agricultural labour continued to be in demand, but the supply of unskilled farm workers was adequate in most places. The changes in rates of wages reported to the department as having come into operation in December resulted in an increase of nearly 140,000*l.* per week in the weekly wages of over 500,000 workpeople. The principal changes affected workpeople in the iron and steel trades and included an increase of 7½ per cent. on basis rates to iron puddlers and millmen in the North of England, Midlands and West of Scotland, whilst other changes affected workpeople in the soap and candle and in the brick, tile, &c., trades, hosiery workers in the Midlands, building trade operatives in Yorkshire and Scotland, and printers and bookbinders in London. Changes in hours of labour in December affected about 75,000 workpeople, whose hours were reduced by an average of nearly 6½ per week; the principal change affected workpeople in the linen industry in Belfast and the North of Ireland.

On Tuesday last, Judge Parry delivered, at Lambeth Court, a reserved judgment under the Workmen's Compensation Act. A Camberwell labourer, named F. Cook, employed at West Drayton, in the erection of aeroplane works for the Air Ministry, had obtained other work and had given the usual 1 hour's notice. He was paid, and on going for his tea-can and food he crossed a plank which tilted; he fell, broke his wrist and was laid up in hospital for 11 weeks. It was contended for the Air Ministry that the accident did not arise out of, or in the course of, the man's employment, the man having stopped work. Judge Parry said it seemed from a number of recent cases that for the purposes of the Act a man might still be in his master's employment after he had been paid off, so long as he was in or about the works for any of the ordinary incidents which were part and parcel of what commonly happened when a workman was finishing his job and clearing off the works. He saw nothing in the case to prevent him from giving effect to the view he held as an arbitrator that the accident in question arose out of and in the course of the man's employment. He therefore made an award for the applicant for 1*l.* per week since the date of the accident, with costs.

THE DESIGN OF CONNECTING RODS FOR INTERNAL-COMBUSTION ENGINES.


DOUBLE-ACTING GAS ENGINE :-
4-CYCLE; DIA.-1050; STROKE-1300; 1850 H.P.; 94 REVS.
Fig.1.
Fig.2
Area at Root of Thread-9·5 Sq.Ins.
4-3½ Bolts 38·4 Sq.Ins. Max. Bolt Strain-~71,500 Lbs. per Sq.Ins.
Sec. Area A-B-31 Sq.Ins.
Max. Strain-1336 Lbs. per Sq.Ins.
Sec. Area H-I-37·2 Sq.Ins.
Max. Strain-3440 Lbs. per Sq.Ins.
Sec. Area E-F-74·4 Sq.Ins.
Max. Strain-3446 Lbs. per Sq.Ins.
Sec. Area C-D-65 Sq.Ins.
Max. Strain-3440 Lbs. per Sq.Ins.
1247 Sq.Ins. Effective Section Area 444,000 Lbs. @ 356 Lbs. per Sq.Ins.
220,000 Lbs.
Tinted Fork represents a Saving of 14400 c.c. = 246 Lbs.

THE STANDARDISATION OF MOTOR TYRES.

TO THE EDITOR OF ENGINEERING.

SIR,—Our attention has been called to reports which have recently appeared in the technical Press of a meeting of European manufacturers, representing England, France, Italy and Belgium, recently held in Paris, when it was decided to adopt certain sizes of pneumatic tyres. As these reports are likely to create a wrong impression, we beg to advise you that this association, the official organisation of the British rubber-tyre industry, had no part in the negotiations referred to, and do not accept the range of standards named.

Our association have for some time had the question of tyre standardisation in hand, and formulated proposals, which were accepted by the official organisations of the car makers, motor cycle and cycle manufacturers, and wheel and rim manufacturers. These proposals were laid before the British Engineering Standards Association, and we understand an interim report will shortly be issued by that body setting forth a complete range of sizes of all classes of pneumatic and solid rubber tyres and rims adopted as British standards.

We shall be glad if you will give publicity to this communication.

Yours faithfully,
THE BRITISH RUBBER TYRE MANUFACTURERS' ASSOCIATION, LIMITED,
W. B. PEAT AND CO.,
General Secretaries.

11, Ironmonger-lane, London, E.C., 2,
January 20, 1920.

THE DESIGN OF CONNECTING RODS FOR INTERNAL-COMBUSTION ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—The accompanying drawings are, I believe, self-explanatory. Having occasion to design the connecting rod for a large marine Diesel engine (cylinders, 32 in. bore by 48 in. stroke), I took the trouble to investigate all the available data that I had accumulated during the past forty years as to that particular detail of large reciprocating engines. I was struck with the discovery that there was no consensus of opinion as to just what strains were permissible, in the fork especially. In any text-book on machine design or applied mechanics the principle of "Combined Bending and Direct Stress" is usually pointed out as controlling the proper dimensions of the fork, and in standard text-books on the steam engine, marine type, such as Bauer and Wilda, it is frequently pointed out that the strains permitted in forks are excessive. For example, Bauer states: "There are rods in use both in very large and small engines, in which the combined compressive and bending stresses are as much as 14,000 lb. per square inch." Wilda mentions, among his examples, an ironclad vessel in the forks of whose connecting rods the combined bending with compressive or tension stress is figured out as no less than 1,300 kg. per square centimetre; or, in other words, almost 18,500 lb. per square inch. Think of it: 18,500 skin tension changing to 18,500 skin compression with about 300,000 alternations per day! One wonders what Wöhler, Bauschinger and Dr. Stanton have to say to such stresses.

Of course, there is only one final and conclusive answer as to the proper size of any part of a machine—does it stand up year after year. If it does, it is strong enough; and no testing machine that can be built is as reliable as the machine itself. We figure stresses for steam engines based on the load at the safety valve, but such stresses are rarely approached in actual service. The case is entirely different with gas engines and oil engines. If we are to accept the conclusions of Messrs. Vickers, pressures in Diesel engines can be advantageously raised to 700 lb. per square inch. Now, even with Diesel engines whose compression was limited to 480 lb. per square inch I have frequently seen the cylinder-relief valves "blow" when manœuvring, and these valves were loaded to 700 lb. per square inch. Personally, I use 600 lb. per square inch as the figure upon which my Diesel engine stresses are based, though 500 lb. per square inch is indicated by most of the underwriters. When we come to the gas engine we might as well take Guldner's 356 lb. per square inch as any other figure, since it appears to agree with the best practice.

From the drawings (published in the technical press) of modern marine Diesel engines I find the unit stresses fairly high in the forks, but one must remember that the engines in question are single-acting, and for that reason the strains on the material are distinctly less. I found one design of fork for a well-known and successful Diesel-engined ship of Dutch origin in which the combined bending and compressive stress at a 45-deg. section exceeded 16,000 lb. per square inch, taking the initial or explosive pressure on the piston as 600 lb. per square inch. All the others examined have figured out less. Assuming the figures on the drawings to be correct as published, and the drawings not distorted, it would appear as if the designer was a very brave man. To have a connecting rod "let go" in the fork while at sea is one of the things one does not care to contemplate. The ship in question has some 12 such connecting rods, and has a most enviable record to its credit—such a record, that many millions of reciprocations for each and every connecting rod of the 12 would appear to be sufficient answer to any adverse criticism.

However, Figs. 1 and 2 accompanying this letter offer a solution to the fork problem that may interest many of your readers, and will present to engineers a startling paradox—the addition of metal to a strut or tie may materially weaken it, even neglecting the inertia. I have chosen a large connecting rod of a famous design, and for a double-acting gas engine, that the stresses might be alternating, tensile and compressive. Had it been possible to secure one for a double-acting Diesel engine, the differences between the old and the new would appear more startling. The dotted outline of the fork as constructed by the M.A.N. is clearly shown, and the solid outline of the substitute fork also.

The tinted portion of Fig. 1 is the exact shape of the fork (one-half) if the lowest unit stresses are to be attained. Every change from the tinted design results in higher skin stresses, as a comparison of the figures relating to the different sections, A—B, C—D, E—F, H—I, J—K and K—L, indicate. As may be seen at a glance, the angle of the fork is 60 deg., which results in loads on its members as given on the axial lines of the tinted portion. These loads divided by the sectional area of each member give the maximum strain (stress) as not exceeding 3,500 lb. per square inch, whereas the skin stress on a 45-deg. section of the M.A.N. fork is shown as exceeding 9,000 lb. per square inch, and lower down on the fork it is still higher. In other words the tinted fork figures out almost three times as strong as the accepted design. There is also less metal in the tinted fork than in the M.A.N. design to the extent of 14,400 cub. cm.—or, in round numbers, 246 lb. The tinted fork might be turned in a lathe, in place of machined in a slotter, and a still greater saving of metal obtained. In this latter case the figures above given would need revision for the metal removed by the turning tool from the edges of the fork. In place of the triangular aperture in the fork, a circular one might be drilled and bored through, but the paradox is, that the fork would be weakened materially whether left solid or with a circular aperture in place of a triangular one. It is also paradoxically true that C—D is stronger than A—B.

Very truly yours,
JOHN L. BOGERT,
Cons. Engineer.

165, Broadway, New York City, December 23, 1919.

AMERICAN HONOURS FOR MR. SCHNEIDER.—We read in the Journal of the American Society of Mechanical Engineers, for December, that on the occasion of the presentation of the gold medal of the Mining and Metallurgical Society of America to Mr. Schneider, the well-known French ironmaster—the first, other than an American, to be so honoured—Dr. Henry M. Howe, Professor Emeritus of Metallurgy at Columbia University, declared that future conflict with Germany was "inevitable." "German treachery persists," he said, "and will persist to plague our descendants. German ideas spring from the nature of the people and not from their form of government. The Germans are avowedly criminal: they avow criminal intent." Engineers from Creusot, he added, had been sent to the United States, when that nation declared war, to help in organising the American steel industry for war. Earlier in the same day, says the same journal, the Stevens Institute of Technology, Hoboken, N.J., conferred the degree of Doctor of Engineering upon Mr. Schneider. The latter, in his address, praised the work of American engineers in France, and suggested that French and American universities should exchange students as well as professors.

T.S.S. "LAWRENCE" FOR THE ROYAL INDIAN MARINE.

CONSTRUCTED FROM THE DESIGNS OF SIR J. H. BILES AND CO., BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, DALMUIR.

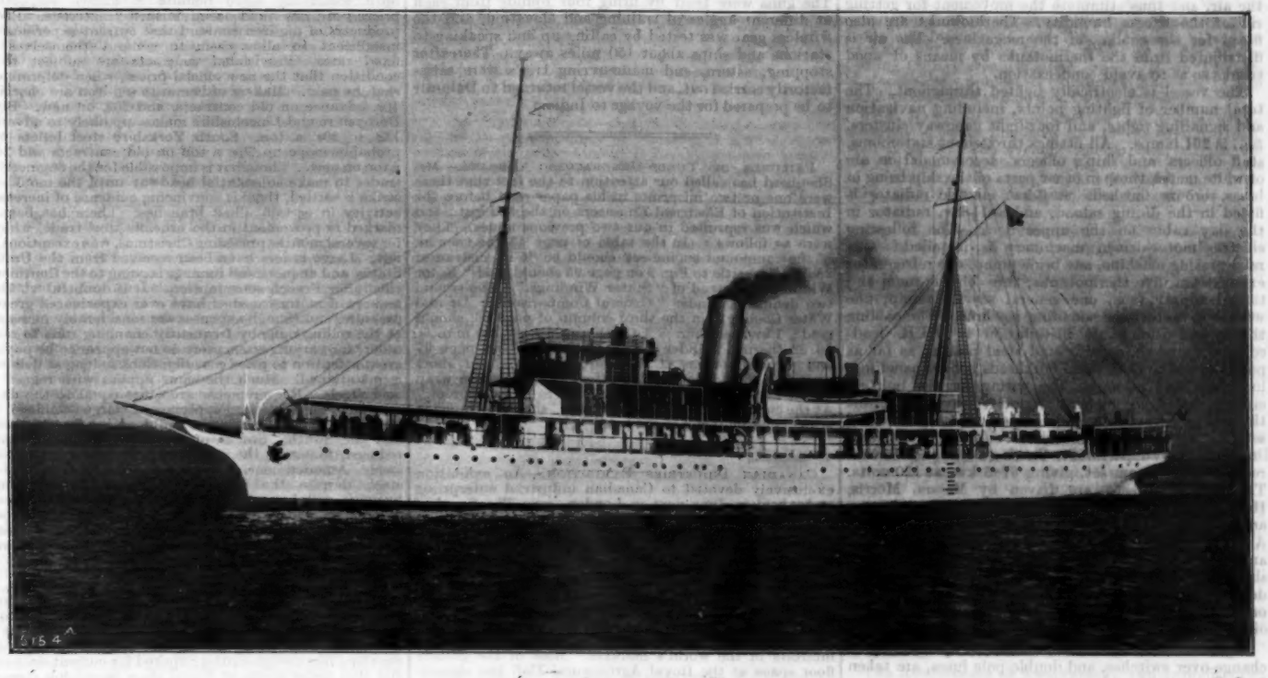


FIG. 1.

WE illustrate on the two-page Plate accompanying this issue, and on this page and page 118, the twin-screw steamer Lawrence, which has been designed for the Government of India by Sir J. H. Biles and Co., and has been built and engined by Messrs. William Beardmore and Co., Limited, Dalmuir. The vessel is for special service in the Persian Gulf, and for the use of the Political Resident in that district. She has been constructed in accordance with the requirements of the Board of Trade, and is of about 1,100 tons gross. As will be seen from the engraving on this page, the vessel is of strikingly graceful and yacht-like appearance. The principal dimensions are :—

	Ft.
Length between perpendiculars	225
Breadth, moulded	34
Depth, moulded, to upper deck midships	20

The decks, of which plans are given in Figs. 3 to 8, on the two-page Plate, are as follows: Navigating bridge, bridge deck, upper deck, main deck, and lower deck. It will be noticed from Fig. 2 that sun decks are fitted over all exposed decks. The vessel is propelled by twin screws driven by geared turbines supplied with steam from oil fired watertube boilers.

The resident's quarters are arranged in a large teak deck-house on the upper deck, forward of the funnel casing. They consist of two special state cabins, each with bath-room adjoining; these state cabins open into a large day cabin at the forward end and into a dining saloon at the after end. This dining saloon is capable of comfortably seating 14 persons. The day cabin is illustrated by Fig. 11 and the dining saloon by Fig. 12, on page 118. A pantry is provided in a continuation of the funnel casing at the after end of the saloon, and communicates with the galley by means of a passage on the port side of the casing. This layout can be seen in Fig. 5, on Plate VIII. Four cabins for six staff officers of the Resident's suite, are in a large teak deck-house, and the bathroom for staff officers is on the upper deck immediately below their cabins. A teak screen, with sliding windows, is fitted at the fore end of the navigating bridge, and a large teak chart-house and teak wheel-house for sheltering the steersman. These various arrangements are shown in our figures.

On the bridge deck at the forward end, accommodation is provided in a large teak deck-house for the commander of the vessel, consisting of day and sleeping cabin and bathroom. The first lieutenant and the two sub-lieutenants have each a cabin. There is an officers' bathroom and mess room adjoining. The commander's sleeping cabin is illustrated in Fig. 13, on page 118. At the after end of the bridge deck is the wireless telegraphy room. Immediately abaft the engine casing on the upper deck, accommodation is provided in three cabins for the chief, first and second engineers.

Washplaces, latrines, native galleys, deck store and lamp-room are arranged in a steel deck-house at the after end of the upper deck. At the extreme fore end of the main deck, store rooms are provided for paints, oils, sails, awnings and canvas, and immediately abaft this, accommodation is arranged for warrant officers, consisting of state rooms for clerk, gunner and assistant surgeon, with mess-room, pantry and bath. A ship's office is also provided in this space.

Between the warrant officers' quarters and the boiler-room bulkhead two compartments are allocated to the second-class passengers, four staterooms being provided for eight passengers, with saloon in centre, pantry, bathroom, lavatory, &c., and a room for the third engineer is also fitted. The saloon has seating accommodation for 12 persons, and in alcoves at the sides sofa seats are provided forming lounges. This saloon is shown in Fig. 14, on page 118. Abaft the boiler-room accommodation is provided in three compartments for petty officers and crew, a hospital and dispensary also being fitted, and two large bunkers for galley coal are arranged, one on each side of the steering engine compartment. The lower deck forward is allocated to store-rooms of various kinds and at the after end refrigerated stores are arranged. The various compartments in the hold at the forward end are utilised for stowage of ammunition, stores, fresh water and oil fuel, fresh water and reserve feed water being also carried in the double bottoms under engines and tunnels at the after end. The total capacity of oil-fuel tanks is about 150 tons, the fresh water capacity is about 50 tons, and the reserve feed about 30 tons. Details of the scantlings and framing are given in Figs. 9 and 10, on Plate VIII.

The armament, which will be principally used for saluting purposes, consists of four 12-pdr. quick-firing guns, placed two on each broadside on the upper deck, two forward and two aft; the magazine and shell-room, which is arranged in the hold at the fore end abaft chain locker, has a capacity for about 800 rounds of ammunition. The small-boat equipment consists of: One 30-ft. paraffin motor launch, capable of 8 knots; two 28-ft. seamless steel lifeboats; one 24-ft. mahogany gig; one 20-ft. whaler or jollyboat fitted with buoyancy tanks, and one 14-ft. dinghy. The motor launch, gig, and one of the lifeboats are stowed on the bridge deck, and the remaining three on the upper deck aft, all being fitted with Welin's davits. The steering gear is by Brown Brothers and Co., Limited, of standard type, with hand gear combined, and is controlled from the bridge by telemotor. The Marconi wireless telegraphy installation is suitable for the transmission of messages over a range of 200 miles, day or night. The windlass is of Napier Brothers' make, having vertical engines and two warping ends.

The refrigerating and ice-making machinery is by Messrs. Seager's, Limited, and is of the multiple effect compression system constructed by them. The machine is of the horizontal motor-geared type, and its duties are not only to keep at a proper temperature the meat and vegetable chambers, but also to make ice and cool the living quarters, &c. This machine takes a primary evaporation for cooling the CO_2 gas to liquitaction before it is allowed to enter the evaporator, the two evaporations being taken in multiple effect compression as two charges in the same compressor. This system of evaporation and compression has the effect of maintaining a high power of refrigeration in any country, and is particularly suitable for the hot climate for which this vessel is intended. The machine has also been fitted with a new automatic regulator, which has recently been designed, and is suitable for all classes of refrigerating machines which, when once adjusted, will maintain a steadily constant temperature in the evaporator, notwithstanding any slight variation that may take place in the speed of the machine. This regulator has been most severely tested on machinery running at variable speeds, and it has been found that the steadying effect of the automatic control increased the refrigerating output considerably.

Special attention has been paid to the ventilation of the vessel, in view of the very hot climate in which she is to serve, large ventilators being fitted to each room and compartment throughout. Wind scoops of galvanised iron are also provided for each sidelight in the living quarters, and in special positions in deck-houses and elsewhere. Bandy ceiling fans are provided for the various cabins, &c., and in addition, each room in the Resident's and Commander's quarters is provided with a Bandy oscillating fan. The mechanical ventilation of the boat has been carried out by the Thermotank Ventilating Company, of Glasgow, on their well-known principle. Several novel features have been introduced in so far that all the accommodation is supplied with cooled air from cooling thermotanks which are connected with brine pipes lead to the refrigerating machinery. Special drying arrangements are provided so as to reduce the humidity in each of the rooms when the vessel is in wet, tropical climates. The air is

mechanically supplied to, as well as exhausted from, each of the rooms, so as to reduce to a minimum the amount of wet air admitted from the atmosphere. These cooling arrangements are worked in conjunction with Bandy propeller fans arranged in the ceiling of each room, so as to keep a continual movement in the air, and thus stimulate the movement for getting rid of the excess humidity. Thermotanks are also fitted for the cooling of the magazines. The air is distributed from the thermotanks by means of wood trunks so as to avoid condensation.

The vessel is electrically lighted throughout. The total number of lighting points, including navigation and signalling lights, and four-light gangway clusters, &c., is 261 lamps. All fittings throughout staterooms, staff officers' and ship's officers' accommodation are of white metal, those in other parts of the ship being of brass, bronze finished. A 2-kw. electric radiator is fitted in the dining saloon, and a 1½-kw. radiator in the day cabin on the upper deck. The following electric motor-driven machinery is installed: One refrigerating machine, one brine pump, one refrigerator exhaust fan, five thermotanks, three engine-room and tunnel supply fans, one general service pump, one workshop motor, one sounding machine. The cabling throughout the whole installation is V.I.R. lead-covered, clipped to perforated steel plating as far as possible, and to beams and bulkheads behind panelling, in cabins and saloons. The wiring for the lighting circuits has been made sufficiently heavy to permit the use of carbon filament lamps. Three generating sets are installed, all of which are situated in the auxiliary machinery department. One is a Bellis and Morcam reciprocating steam set, giving 67·5 kw. at 120 volts. The two other sets are driven by Messrs. Morris, Henty and Gardner's oil engines, each generator having an output of 31·5 kw., 120 volts, at 600 revolutions. All three generators are by Messrs. W. H. Allen, Son and Co. It is intended that each of the steam set shall take the total load, or that the two oil sets shall do so. The main switchboard has two pairs of bus-bars, one pair being fed by either the steam set, or No. 1 oil set, and the other pair by No. 2 oil set.

Light-distributing circuits, controlled by double-pole change-over switches, and double-pole fuses, are taken from the switchboard.

A complete system of electric bells is installed, four indicator boards, with a total number of 50 shutters and two batteries being fitted. Six loud-speaking Graham's telephones are also fitted, giving direct communication, from the bridge to the engine-room, the bridge to the wheel-house aft, and the engine-room to the boiler-room. Power is supplied from a battery.

The vessel is propelled by twin-screws driven by steam turbines operating single-reduction double-helical gearing. The turbines are of the Parsons compound type, and each set consists of a high pressure and low-pressure turbine, each coupled to an independent pinion. An astern turbine is incorporated in each low-pressure casing. The high-pressure turbine and astern turbine are provided with impulse wheels, the ahead inlet being controlled by nozzle valves suitably arranged for cruising and full-power conditions. The maximum designed revolutions of the turbines are 3,480 per minute and propellers 215 per minute. The double-helical gearing was cut by special machine in the builders' works, and proved eminently satisfactory and silent in operation when running at full speed. The shafting is of Boardmore steel. The propellers are of solid bronze, and the thrust blocks of the Michell type. The turbines exhaust to surface condensers of the Weir Uniflux type, the condensate being extracted by Weir dual air pumps.

The steam generating plant consists of two Babcock and Wilcox boilers designed to operate at 200 lb., of a total heating surface of 3,930 sq. ft., fired by oil only, a complete equipment of oil pumps, heater, filters, &c., being provided. The boilers are arranged on the closed stokehold system, the necessary forced draught being supplied by two fans and engines. A very complete installation of auxiliary machinery is supplied, and includes two evaporators, a distilling condenser, fresh water pump, two feed pumps, feed heater, one sanitary pump, two general service pumps (one electrically-driven for harbour use), two forced lubrication pumps and two oil fuel pumps.

The specification stipulated that the vessel must carry not less than 220 tons deadweight on trial draught and that any ballast necessary to ensure a metacentric height of 20 in. in the light condition was also to be carried on trial in addition to the 220 tons. The vessel fulfilled these conditions regarding deadweight and stability in both cases, with a slight margin in hand, no ballast being required for stability purposes. The trials occupied two days, the first day being devoted to progressive runs on the measured mile and steering and circle trials. The speed specified was 15 knots, and on the second day an extended sea trial was carried out at the revolutions ascertained to correspond to this speed. During this trial the vessel was run over the measured mile and attained a speed of 15·3 knots as a mean of two runs, one with and one against the tide, the shaft horse-power being about 1,800. The mean shaft horse-power for the sea trial was about 1,700, the propeller revolutions being about 210, and the corresponding speed slightly in excess of 15 knots. The guns were tried by firing four rounds from each at different angles of training and elevation, and the wireless gear was tested by calling-up and speaking to stations and ships about 150 miles away. Thereafter stopping, astern, and manœuvring trials were satisfactorily carried out, and the vessel returned to Dalmuir to be prepared for the voyage to India.

FAILURES OF TURBO-GENERATORS: ERRATA.—Mr. Shepherd has called our attention to the fact that there were one or two misprints in his paper read before the Institution of Electrical Engineers on the 8th inst., and which was reprinted in our two previous issues. They were as follows: In the table of page 43 the vacuum of the compound engine set should be 26 in. instead of 28 in. The title to Fig. 8 on page 95 should read "Rotor Windings," instead of "Stator Windings." The second two definitions under "General Comparison of Air and Water Cooling," in the third column of page 96, should read: 1 kw. per hour = 3,412 therms; 1 kw. per min. = 56·82 therms. Under "Ship Propulsion" on page 97 and at the bottom of the third column, "for short periods" should be inserted after "The micanite wrap on the stator bars may be considered to be waterproof." At the end of this section "generally" should be inserted after "marine turbines are not."

CANADIAN INDUSTRIES EXHIBITION.—An exhibition exclusively devoted to Canadian industrial enterprises to be held in June next in London, says *The Board of Trade Journal*, will have the support of the Canadian Trade Commission, the Canadian Manufacturers' Association, and the Canadian Mission in London. The organisation is in the hands of Mr. H. Greville Montgomery, promoter of the building trades and other successful exhibitions, who, in company with Mr. Lloyd Harris, of the Canadian Mission in London, recently paid a visit to Canada personally to enlist the support of firms particularly interested in promoting Canadian interests in the world's markets. Most of the ground floor space at the Royal Agricultural Hall has already been definitely allotted to leading firms, the exhibits comprising grain elevators, separators, woodworking machinery, tractors, ready-made houses, hardware, steel products, &c., &c. All information can be obtained from the offices of the exhibition, 43, Essex-street, Strand, W.C. 2.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.—The Lord President of the Council has approved the appointment of Colonel Sir Frederic Nathan, K.B.E., late R.A., to be Power Alcohol Investigation Officer under the Fuel Research Board of the Department of Scientific and Industrial Research. Sir Frederic Nathan, before the war, was Superintendent of the Royal Gunpowder Factory at Waltham Abbey, and, later, works manager of Messrs. Nobel's Explosives Factory, Ardeer; he was the officer in control of alcohol under the Ministry of Munitions during the war, and Chairman of the Production Section of the Interdepartmental Committee on the production and utilisation of alcohol for power and traction purposes. He has been entrusted with the survey of the present position and with making proposals to the Board for such experiment and research as may from time to time appear to be necessary. Professor Pierce Purcell, who was secretary of the Irish Peat Inquiry Committee, has been appointed to act as Peat Investigation Officer under the Fuel Research Board. The duties of the Peat Investigation Officer will similarly be to keep the Board informed of all progress in connection with research into the utilisation of peat, to continue and extend experiments on the mechanical cutting and winning of peat, and to make arrangements for careful tests of the use of peat as a fuel under boilers.

TRADE WITH THE DUTCH EAST INDIES.—The United States Trade Commissioner, John A. Fowler, says *The Iron Age*, has prepared a report for the Department of Commerce on the market for iron and steel in the Dutch East Indies. The first requisite of a successful business, he states, is able representation in the field. Before such action is taken, however, he recommends that American steel and iron-producing companies inquire carefully into the expenses of such an organisation. He declares that unless these companies remain permanently in the market there, withdrawal after a short exploitation would do American business more harm than good. He reports that there is no question about the amount of business that can be done in iron and steel in the Dutch East Indies. With 200 or more sugar "centrals," thousands of miles of light rails are constantly needed, and under the present plans of the Dutch East Indian Government, 10,000 miles of railway will eventually be built. Government work planned during the next few years will alone require 45,100 tons of cast-iron piping, to say nothing of the private needs of oil companies for pipe lines, and the demand for reinforcing material on concrete construction work. As soon as conditions become somewhat normal, new mining ventures will be opened up in what is potentially a great mining country, and the supply of machinery for this work will be imported entirely from abroad.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Inquiries for all classes of manufactured goods, and particularly for mild steel and tools for shipment, are plentiful, but manufacturers show some hesitation about fixing up long-dated contracts until something more definite is known respecting prices of raw and semi-finished materials. Local producers of pig-iron contend that current experience is insufficient to allow them to commit themselves to fixed rates. Provisional contracts are subject to a condition that the new official prices, when determined, shal. be paid. Makers of hematite pig-iron are charging 10*s.* advance on old contracts, and 20*s.* on new. Both Derbyshire and Lincolnshire makes are likely to advance 15*s.* to 20*s.* a ton. South Yorkshire steel billets will probably move up 20*s.* a ton on old contracts and 30*s.* a ton on new. Though it is impossible for the engineering trades to make substantial headway until the moulders' strike is settled, there is convincing evidence of increased activity in certain allied branches. There has been a marked improvement in the crucible steel trade, which, for several months preceding Christmas, was exceptionally flat. Large orders have been received from the United States, and an increased tonnage is going to the Continent, chiefly for French consumption. It is doubtful whether makers of motor-car steel have ever experienced greater pressure, and though expenses are considerably increased at the rolling mills by frequently changing rolls to meet orders for varying sizes, users do not appear to be paying great attention to price considerations so long as delivery is maintained. Much the same applies with regard to acid steels. Requirements are quite equal to the daily output. Sheffield is supplying a large tonnage of structural steel for wagon builders in the Midlands and the South. Stocks of alloys are gradually being reduced, following the increased demand for high-speed steel. America continues a good buyer of this class of steel, despite the inequalities of exchange, though business will have to expand still further if the level of pre-war trade with America is to be reached. Toolmakers are all booked up for several months ahead. The pressure on file manufacture promises to reach boom proportions, despite the much wider adoption of forging plant and labour-saving devices.

South Yorkshire Coal Trade.—There appears considerable conflict of opinion as to whether famine conditions do or do not exist in the house coal trade. It is a fact, however, that small dealers are unable to secure anything like the quantities required for current delivery, and that order books at depots show increasing arrears. Only the continuance of mild, unseasonable weather prevents the shortage getting seriously out of hand. Increased consumption of manufacturing fuels has brought renewed pressure on deliveries. Some complaints are heard of shortage, but generally the staple trades are well supplied, and are not without reserve stocks. Railway companies and inland works appear to be faring very favourably. Scarcity is much more pronounced in regard to gas and electricity concerns, which have considerable difficulty in maintaining full supplies and at the same time preserving minimum stocks against emergency. Cokes are a strong market, and are difficult to procure. Quotations:—Best branch hand-picked, 23*s.* to 24*s.*; Barnsley best silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.* nutty, 23*s.* to 24*s.*; smalls, 19*s.* 6*d.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—An outstanding feature of the Cleveland pig-iron trade is the phenomenally high rates neutrals are prepared to pay. The unprecedented figure of 220*s.* for No. 3 has been paid for Scandinavia, but little iron is available for such trade. Producers are devoting most attention to the needs of home consumers, and the allies. Supply of iron continues inadequate, but it is gratifying to have to announce considerable improvement in rail-borne deliveries due to the much better supply of trucks. Possibly effort will be made shortly to increase output of Cleveland pig-iron by blowing-in of idle furnaces, if raw material can be obtained for that purpose. To home customers, No. 1 Cleveland pig-iron is 182*s.* 6*d.*, and No. 3, as well as all the lower qualities of Cleveland iron, is 175*s.*; and for shipment to France, Belgium and Italy, No. 1 is 187*s.* 6*d.* and No. 3 and inferior grades are 180*s.*

Hematite Iron.—East Coast hematite is fairly plentiful, and in only moderate request as compared with demand for Cleveland pig-iron. Producers, however, are by no means pressing sales. Home business is on a rather better scale, but inquiry from abroad shows little or no improvement, and, owing to continued adverse rate of exchange, Italy—one of the best customers of this district—is taking no more iron than is essential. No. 1 is 222*s.* 6*d.*, and mixed Nos. are 220*s.* for home use; and for shipment to France, Belgium and Italy the former is 227*s.* 6*d.* and the latter are 225*s.*; whilst for export to other countries, the minimum quotation for hematite is 230*s.*

Foreign Ore.—Some consumers of foreign ore are in the market to buy, but they hesitate to pay the prices asked. Sellers, however, take a very firm stand, and confidently anticipate considerable business, at high rates, in the very near future, though consumers declare that prices

have become prohibitive. With the freight Bilbao-Middlesbrough now 33*s.*, the price of rubio, of 50 per cent. quality, cannot well be put under 63*s.* c.i.f. Tees.

Manufactured Iron and Steel.—There is little new to report concerning the finished iron and steel industries. Customers are anxious to place orders at the rates ruling, but they experienced the greatest difficulty in finding manufacturers in a position to enter into further contracts, all firms being overwhelmed with work. Consumers' needs at home and abroad are so great that price is almost a matter of secondary consideration, the all-important question with customers being that of delivery. The following are among the principal market quotations:—Common iron bars, 23*l.*; marked bars, 25*l.* 10*s.*; small steel bars, 22*l.*; steel strip, 27*l.* 10*s.*; steel hoops, 27*l.* 10*s.*; steel ship, bridge and tank plate, 20*l.*; steel boiler plates, 23*l.*; steel angles, and steel joists, each 19*l.* 10*s.*; heavy sections of steel rails, 18*l.* 15*s.*; and galvanised sheets, 47*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Market.—The coal market is dislocated by a stoppage of work at the Barry Docks consequent on a dispute between the Dockers' Union and two dock-gatemen. The latter, some time ago applied for permission to transfer to the National Union of Railwaymen, and as this request had been refused, declined to pay their contributions to the union. The matter has now been brought to a head, as other members of the union at Barry, numbering some 2,500, refused to work with the men in question, and in consequence the work of the port has come to an automatic standstill. This morning only six coal tips were working, because vessels cannot be moved to and from the tips, as the boatmen are out and it is not practicable to shift vessels under their own steam, because it is considered probable that the trimmers would refuse to handle such tonnage. The Barry Railway Company have been requested to suspend the dock-gatemen in question, but they have declined to take action, as they consider the dispute concerns the Dockers' Union and the men, and must be settled by them. Unless an immediate solution of the difficulty is reached the prospects are very black for to-morrow, it is expected that a number of collieries will be rendered idle, and some thousands of men thrown out of work because of a shortage of empty wagons.

[Late on Wednesday night the dispute was settled, the Barry Railway Company agreeing to transfer the men in question to another department not associated with the Docks; an immediate resumption of work will take place.]

Actual business on the coal market is quiet as buyers are holding off, where practicable, anticipating that more coal will be available for shipment at ports not affected by the stoppage, and that sellers will modify their ideas of values. Generally 110*s.* is asked for best large and 92*s.* 6*d.* for first quality steam smalls, but collieries affected by the Barry stoppage are ready to discount these prices by at least 10*s.* a ton to buyers able to take immediate delivery. Only in exceptional cases, however, can buyers take advantage of the position, for loading accommodation is congested, and in the majority of cases cargoes have already been arranged for vessels in dock. Coke is exceedingly scarce and commands up to 130*s.* for export and up to 80*s.* for home consumption. Patent fuel is only available in small parcels at 110*s.*

The Iron and Steel Trades.—The Joint Industrial Council for the South Wales tin-plate trade, on Monday had under consideration the application of the workers for a 50 per cent. increase in wages, and it was eventually agreed that a special bonus of 40 per cent. be paid on base rates to all operatives till April 3. In the meantime future wages will be the subject of negotiation. No war percentage bonus is to be paid on the 40 per cent., and the new rates work out as follows: For piece-workers, on 200 boxes, say, at 3*d.* per box, the earnings would equal 2*l.* 10*s.*, war percentage at 120 per cent., 3*l.*, and special 40 per cent. on base rates 1*l.*, making a total of 6*l.* 10*s.* Maintenance men, six days, at 5*s.* per day, 1*l.* 10*s.*, war percentage 2*l.* 2*s.*, 40 per cent. on base rates 12*s.*, making 4*l.* 4*s.* As a number of firms are working on old contracts taken at 32*s.* per box, compared with the current price of 64*s.*, the increased wages are regarded as a serious factor, though it is believed that the industry will benefit in the long run by the men's claim not having been allowed to hang over the market. The demand for tin plates is as pressing as ever, and makers have no difficulty in upholding prices.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—There has been no slackening off in the demand for steel material during the past week, and requests for deliveries keep rolling in steadily, with the result that all the plant available, kept going at full speed, is not able to cope with the demand. Inquiries both on home and foreign account are on a large scale, and the tonnage of new business on offer, despite the high prices which steel-makers now find it necessary to charge for their products, is exceedingly heavy. Some buyers are even willing to pay a little more if only they could receive the assurance of a near date shipment, because of the urgent needs of their friends abroad, but owing to the very pressing demands of the home consumers there is little available for export. In the matter of ship plates every ton turned out is going rapidly into consumption, and still the cry is for more. Boiler plates are also in demand, and sections are again finding a ready sale. Makers of black sheets are being much pressed for deliveries, and their difficulty is to meet the needs of their customers whose requirements for the heavier gauges in particular they scarcely seem able to satisfy. Export orders are accounting for a fair tonnage now, and much of it is going East. Prices all round are strong, but these count less than delivery, which is nowadays the essential thing.

Malleable Iron Trade.—The position of the West of Scotland malleable iron trade is unchanged and much activity is general at the different works. The bulk of the present output is still being used up at home, and consequently the export trade must needs wait until the makers can spare any material for the overseas market. Prices have been advanced owing to the increased cost of production, due to the rises in the railway rates.

Scotch Pig-Iron Trade.—Active conditions continue to rule in the pig-iron trade of Scotland, and a large proportion of the present make is being consumed locally. The new quotations are not retarding business, as large quantities are being asked for daily, and inquiries for export are also very good. In the latter connection some quite fair lines have recently gone through, in foundry iron chiefly. There is a very good demand from the local steel-makers for hematite iron, and deliveries are very satisfactory. Prices continue to rule strong.

Institution of Engineers and Shipbuilders in Scotland.—Dr. Blackwood Murray presided at a meeting of the Institution of Engineers and Shipbuilders in Scotland last night, in the Institute headquarters, Elmbank-street, Glasgow. The meeting was held jointly with the members of the Scottish branch of the Royal Aeronautical Society, who received a hearty welcome from the chairman. A paper was read by Mr. J. S. Nicholson, B.Sc., Glasgow University, on "The Development of Metal Construction in Aircraft." The annual James Watt dinner of the Institution takes place on Friday evening of this week, in the Grosvenor Restaurant, Glasgow, when the president, Dr. Blackwood Murray, will occupy the chair.

FUELS FOR MOTOR VEHICLES: ERRATUM.—We much regret that in the leading article on this subject published in our last issue a printer's error escaped our notice. On page 86 *ante* we referred to the remarks of Mr. H. S. Broom, of Messrs. Broom and Wade, but in both cases the name Brown was printed instead of Broom. The error, much as we regret it, will probably give rise to but little confusion, as the name of the firm is so familiar to engineers.

THE LATE MR. GEORGE AINSWORTH.—We regret to announce the death which occurred suddenly on the 18th inst., at The Hall, Consett, of Mr. George Ainsworth, the late general manager of the Consett Iron Company. Mr. Ainsworth was in his seventieth year. He retired from the position of general manager of the Consett Company on March 31 of last year. He had been in the service of the company for about forty years and was selected as general works manager at the annual meeting held in Newcastle in August, 1894, when the late Mr. William Jenkins resigned the position of general manager. He was appointed general manager in 1905 and had under his supervision all the productive industries associated with the firm. Mr. Ainsworth became a member of the Iron and Steel Institute in 1872, and was made a Member of Council in 1900; at the time of his death he was one of the vice-presidents. He was also a member of the Government Industrial Commission; president of the British Steel Ingot Makers' Association; a member of the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England; chairman of the Shotley Bridge and Consett Gas Company; ex-chairman of the Consett New Town Hall Company Limited; and was on the Board of several other local institutions.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION—ADDENDUM.—We much regret that in the description of Messrs. Tinsley's exhibits a whole paragraph was accidentally left out in the first column of page 88 of last week's issue. The description of the artificial track circuit should have been followed by the missing paragraph: "The last novelty of Messrs. Tinsley we have to mention is Dr. C. V. Drysdale's stroboscopic speed indicator, which is fitted with a neon tube, as developed by Dr. Aston and others at the Royal Aircraft Factory, for shaft speeds from 50 r.p.m. up to 6,000 r.p.m. The stroboscopic disc rotates on a ball bearing joined by a flexible shaft to the motor shaft; a tuning fork is connected to a small induction coil worked by a 2-volt battery, the secondary of which comprises the neon tube. By the oscillations of the tuning light flashes are produced at intervals of 1/50th of a second." On the stroboscopic disc are marked four geometric figures, a square, a pentagon, a hexagon and a 30-point star. When any one of these figures turns through the angle subtended by two of its corners or points in the interval of 1/50th second, it will occupy the same apparent position at each flash and will appear stationary. Thus when the star rotates at 1/30th revolution in 1/50th second (1/3,000 minute), the star will appear stationary, and this will occur at any multiple of 1/30th revolution per 1/50th second, that is to say, for 100 r.p.m., 200 r.p.m., 300 r.p.m., &c. At the intermediate values of 50 r.p.m., 150 r.p.m., 250 r.p.m., &c., the star will look double. The hexagon will appear stationary at 500 r.p.m. 1,000 r.p.m., 2,000 r.p.m., the pentagon and square at 600 r.p.m. and 750 r.p.m. respectively, with intermediate doubles and trebles. By combining stationary appearances the speed of rotation can be kept constant at any desired value, and any creeping off or up in the shaft speed will immediately become visible by the slow rotation of the geometric figures in the one or other direction. This completes the description.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 23, at 6 p.m., at the Institution, Storey's Gate, St. James's Park, S.W. Paper to be read: "Recent Advances in Utilisation of Water Power," by Mr. Eric M. Bergstrom, of London, Associate Member.

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, January 24, the Fourth Lecture of session 1919–20 will be given in the Assembly Room of the Cycling Club, Cavendish-street, by Mr. H. E. Thomas, of Manchester. Subject: "Automatic Machines." The chair will be taken at 6.30 p.m. by the president.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday evening, January 24, at the Grand Hotel, Aytoun-street. The evening will be reserved for the reading and discussion of a paper on "Some Phases of Workshop Management," by Mr. H. Mensforth, C.B.E., M.Sc., M.I.Mech.E., Member. The chair will be taken at 7 p.m.

THE BRADFORD ENGINEERING SOCIETY.—Monday, January 26, at 7.45 p.m., in the Hall of the Bradford Technical College, when a Lecture will be given by Mr. H. A. Jones, B.Sc.(Manchester), on "Boiler and Economiser Setting."

THE ROYAL SOCIETY OF ARTS.—Monday, January 26, at 8 p.m.: Cantor Lecture, "Aircraft Photography in War and Peace," by Captain H. Hamshaw Thomas, M.B.E., M.A., F.G.S., Fellow of Downing College, Cambridge, and formerly of the Royal Air Force. (Lecture II.) Wednesday, January 28, at 4.30 p.m.: Ordinary Meeting, "The Ruin and Restoration of Belgium," by Sir Cecil Hertslet, late H.B.M. Consul-General for Belgium. Monsieur Emile Cammaerts will preside. The paper will be illustrated by lantern views.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 27, at 5.30 p.m. Papers to be further discussed: "Whitby Harbour Improvement," by Mr. James Mitchell, M.Inst.C.E.; "The Design of Harbours and Breakwaters with a view to the Reduction of Wave-action within Them," by Mr. Ralph Frederick Hindmarsh, M.Inst.C.E.; "Wave-action in Harbour Areas; with Special Reference to Works for Reducing it at Blyth and Whitby Harbours," by Mr. John Watt Sandeman, M.Inst.C.E.; "The Improvement of the Entrance to Sunderland Harbour, with Reference to the Reduction of Wave-action," by Mr. William Simpson, O.B.E., M.Inst.C.E.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—Tuesday, January 27, at 7.30 p.m., at The Arts Building, Liverpool University, Mr. S. Clowes, Wh.Ex., on "Elementary Calculus," being the sixth lecture of series. Thursday, January 29, at 7.30 p.m., at the Liverpool University Engineering Lecture Theatre, Dr. H. Whichells (Hon. Secretary, Liverpool Astronomical Society), on "The Scenery of the Heavens."

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, January 27, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London, when a discussion on "Colour-matching by Natural and Artificial Light" will be opened by Mr. W. C. Martin (Department of Technical Optics, Imperial College of Science).

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, January 27, at 6.30 p.m., Meeting at the Institute. Paper to be discussed: "Oil from Well to Consumer," by Mr. H. T. Williams.

THE WIRELESS SOCIETY OF LONDON.—Thursday, January 29, at 6 p.m., Meeting at the Institution of Civil Engineers, when a Lecture, illustrated by experiments and lantern slides, will be given by Mr. R. C. Clinker, entitled "A Portable Valve Set and Some Properties of C.W. Circuits."

THE INSTITUTION OF MECHANICAL ENGINEERS, MANCHESTER MEETING.—Thursday, January 29, at 7 p.m., at the Engineers' Club, Manchester, when Mr. Eric M. Bergestrom will read his paper on "Recent Advances in the Utilisation of Water Power." The chair will be taken by Mr. J. Phillips Bedson, M.I.Mech.E.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, January 30, at 9 p.m., a discourse will be delivered by Mr. Sidney G. Brown, F.R.S., M.I.E.E., M.R.I. The subject is "The Gyrostatic Compass." Afternoon Lectures, at 3 p.m.: Tuesday, January 27, Professor G. Elliot Smith, M.D., F.R.S., F.R.C.P., on "The Evolution of Man and the Early History of Civilisation: 1. Man's Origin": Thursday, January 29, Mr. Richard R. Terry, Mus.Doc., F.R.C.O., on "Renaissance Music in Italy and England" (with musical illustrations) (Lecture III); Saturday, January 31, Sir Frank Watson Dyson, LL.D., F.R.S., Astronomer Royal, on "The Astronomical Evidence Bearing on Einstein's Theory of Gravitation: 1. Movement of the Perihelion of Mercury."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 30, at 7.30 p.m., "The Manufacture of Hydrogen Gas by the Silicol Process for Airships and Commercial Purpose," by Mr. G. E. Lygo, Member.

FEDERATION OF BRITISH INDUSTRIES.—Mr. G. C Musgrave has been appointed as a representative of the Federation in Cuba. He will be sailing at the end of this month. His address will be communicated to the Press as soon as he has taken suitable offices on his arrival. Mr. Antonio Gibbon, whose address is 7A, Naranja 179, Mexico, D.F., has been appointed as a federation's representative. Arrangements for a permanent secretary in Holland are being made, and details with regard to this will be given as soon as they are complete.

THE ROYAL INDIAN MARINE T.S.S. "LAWRENCE."

CONSTRUCTED TO THE DESIGNS OF SIR J. H. BILES AND CO., BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, DALMUIR.

(*For Description, see Page* 115.)

FIG. 11. THE RESIDENT'S DAY CABIN.

FIG. 12. THE RESIDENT'S DINING SALOON.

FIG. 13. THE COMMANDER'S SLEEPING CABIN.

FIG. 14. THE SECOND-CLASS DINING SALOON.

T.S.S. "LAWRENCE" FOR THE ROYAL INDIAN MARINE.

CONSTRUCTED FROM THE DESIGNS OF SIR J. H. BILES AND CO., BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, DALMUIR.

(*For Description, see Page* 115.)

Fig.2.

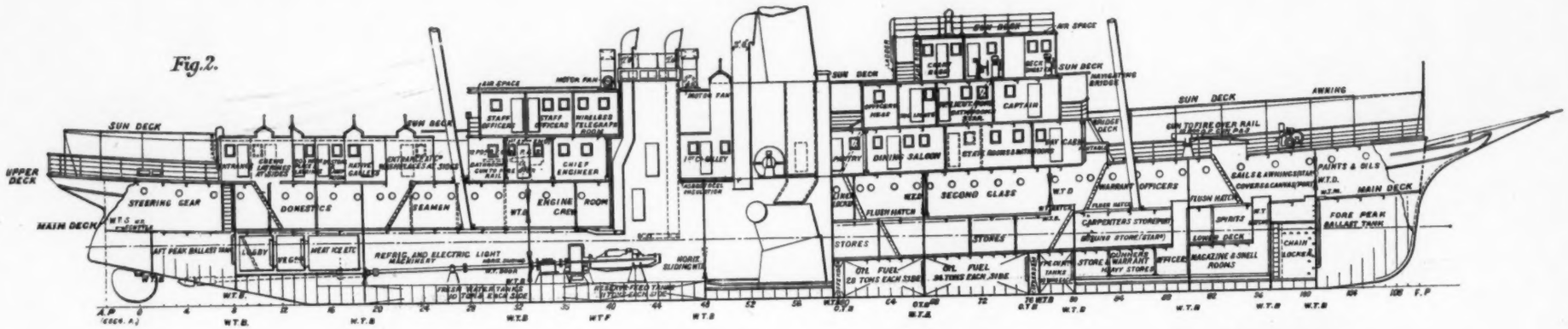


Fig.3. BRIDGE DECK

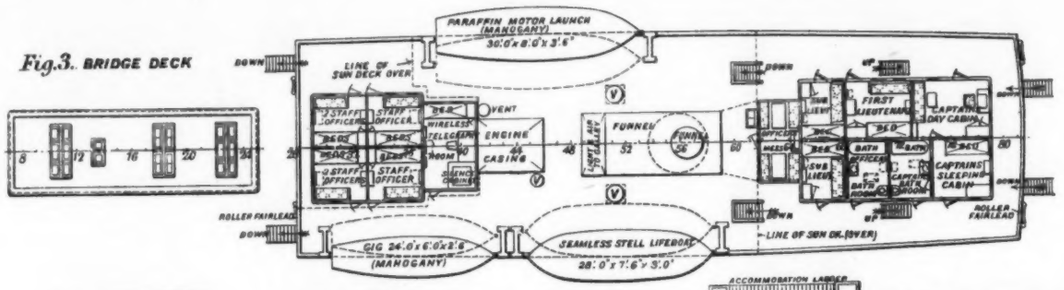


Fig.4. NAVIGATING BRIDGE.

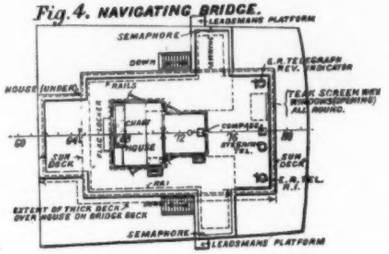


Fig.5. UPPER DECK.

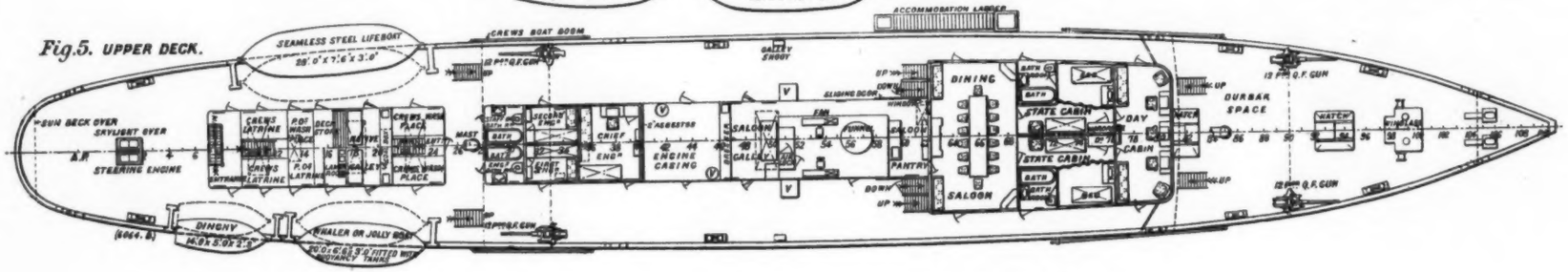


Fig.6. MAIN DECK.

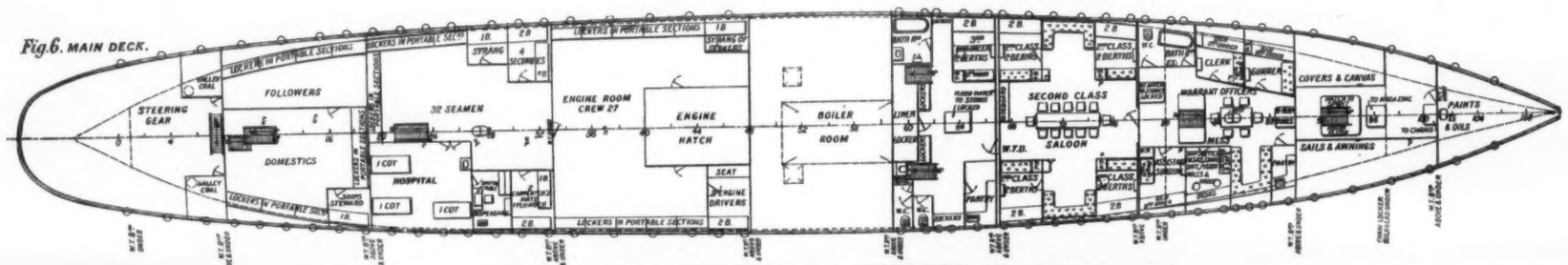


Fig.7. LOWER DECK.

Fig.7. LOWER DECK.

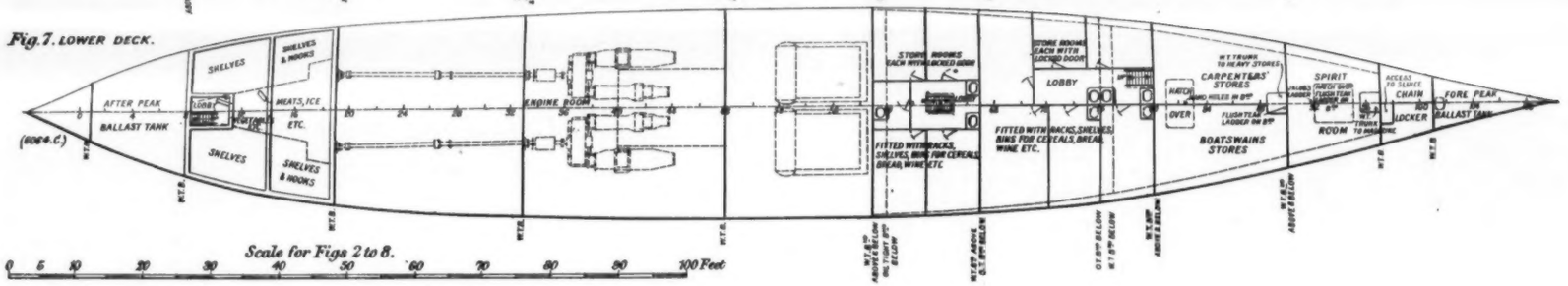
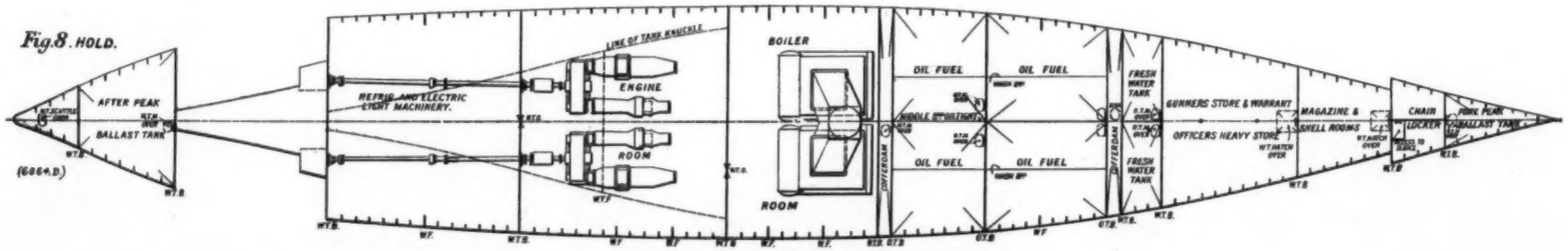
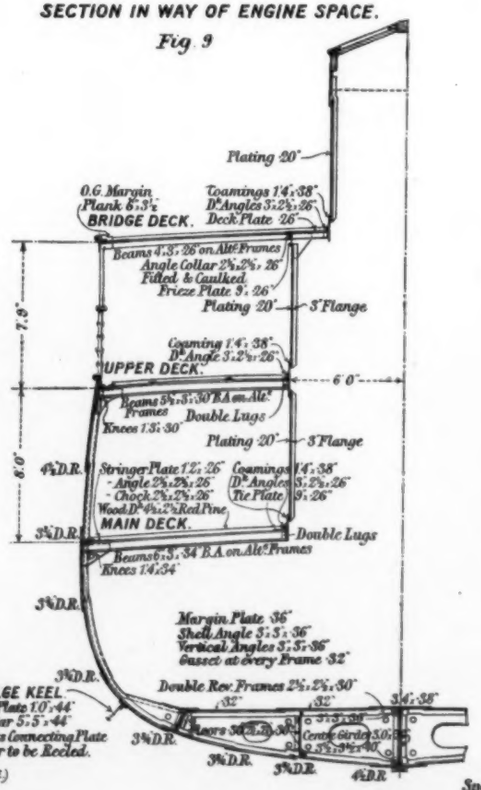

AFTER PEAK BALLAST TANK
SHELVES
SHELVES & HOOKS
MEATS, ICE ETC.
ENGINE ROOM
STORE ROOMS EACH WITH LOCKED DOOR
LOBBY
FITTED WITH RACKS, SHELVES, BINS FOR CEREALS, BREAD, WINE, ETC.
CARPENTERS' STORES
BOATSWAINS STORES
SPIRIT ROOM
CHAIN LOCKER
FORE PEAK BALLAST TANK
Scale for Figs 2 to 8.
0 5 10 20 30 40 50 60 70 80 90 100 Feet

Fig.8. HOLD.



SECTION IN WAY OF ENGINE SPACE.

Fig 9



Scale for Fig 9 and 10.

Ft 5 4 3 2 1 0 5 10 15 Feet

SCANTLINGS.

Stem - 6"x1⅛ Rolled Steel
Stern Frame A Forging or Steel Casting
Rudder - 8" Dia. of Stock 4" Dia. at Head.

FRAMING.

Frames spaced 2'0" apart Fore & Aft.

Frames in way of Machinery Space and Tunnel Recess to be 3½"x3½"x30" Angles. Elsewhere they are to be 3½"x3½"x28" Angles. In way of Lower Deck Forward they are to be Cut and Bracketed; in way of the Tank under Engines they are to be Cut and Bracketed at the Margin Plate; elsewhere they are to be Continuous from Keel to Upper Deck.

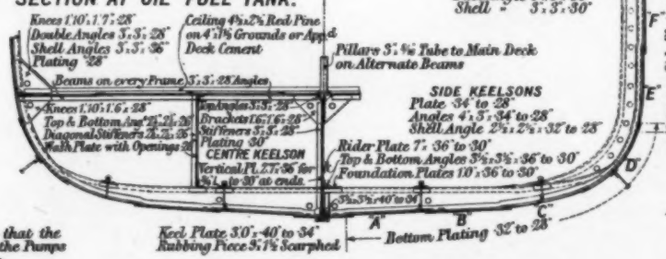
Reverse Frames 3"x3"x30" in Machinery Space and Tunnel Recess, and 2½"x2½"x28" elsewhere; they are to be carried to Upper Deck in way of Peaks, Machinery Space and Tunnel Recess; elsewhere they are to run alternately to Upper and Main Decks. They are to be doubled from Bilge to Bilge in way of Tank under Engines.

Web Frames 12"x30" with Face Bar 5"x3"x34" Angle, one in way of Fuel Tank, two in Boiler Room, two in Engine Room, one in Tunnel Recess

Floors. Ordinary Floors in way of Boiler Room and Tanks 16"x34", under Boilers 44", elsewhere 14"x34" for ⅔ L to 30" at Ends. Floors in way of Double Bottom 30" cut at Margin Plate and Centre Girder.

Bulkheads. - Watertight and Oiltight Bulkheads as per Arrangement Plan; Engine and Boiler Room Bulkheads to be ⅜". Flanged 7" for Stiffening. Bulkheads at Ends to be 10/32" Flanged 5" below and 4" above Lower Deck Bulkhead. Frames 4"x4"x⅜" Single Stiffeners 2'0" apart Kneed Top and Bottom to Decks.

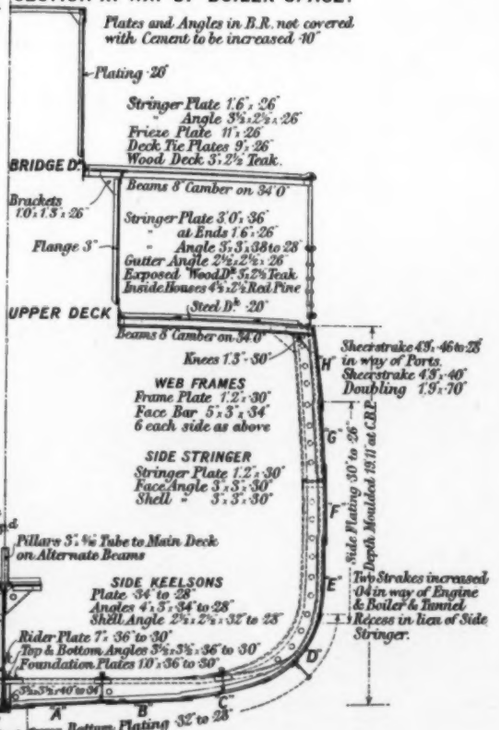
SECTION AT OIL FUEL TANK.


Knees 10"x10"x7"x28"
Double Angles 3"x3"x28"
Shell Angles 3"x3"x36"
Plating 28"
Ceiling 4½"x2" Red.Pine on 4"x1" Grounds or Approved Deck Cement
Pillars 3" ⅜" Tube to Main Deck on Alternate Beams
Beams on every Frame 3"x3"x28" Angles
Knees 10"x10"x16"x28"
Top & Bottom Angles 3"x3"x28"
Diagonal Stiffeners 2½"x2½"x35"
Wash Plate with Openings
SIDE KEELSONS
Plate 34" to 28"
Angles 4"x3"x34" to 28"
Shell Angle 2½"x2½"x32" to 28"
Rider Plate 7"x36" to 30"
Top & Bottom Angles 3½"x3½"x36" to 30"
Foundation Plates 10"x36" to 30"
Brackets 16"x16"x28"
Stiffeners 3"x3"x28"
Plating 30"
CENTRE KEELSON
Vertical Pl. 27"x36" for 4'-1" to 30" at ends.
Keel Plate 30"x40" to 34"
Rubbing Piece 5"x1½" Scarphed
Bottom Plating 32" to 28"

Special Care to be taken that the Course for Bilge Water to the Pumps is free from Obstruction.

SECTION IN WAY OF BOILER SPACE.

Fig.10.


Plates and Angles in B.R. not covered with Cement to be increased 10"
Plating 26"
Stringer Plate 16"x26"
Angle 3½"x2½"x26"
Frieze Plate 11"x26"
Deck Tie Plates 9"x26"
Wood Deck 3"x2½" Teak.
BRIDGE D.k
Beams 8" Camber on 34'0"
Brackets 10"x13"x26"
Stringer Plate 30"x36"
at Ends 16"x26"
Angle 3"x3"x38 to 28"
Gutter Angle 2½"x2½"x26"
Exposed Wood D.k 3"x2½" Teak.
Inside Houses 4½"x2"x Red.Pine
Flange 3"
UPPER DECK
Steel D.k 20"
Beams 8" Camber on 34'0"
Knees 13"x30"
WEB FRAMES
Frame Plate 12"x30"
Face Bar 5"x3"x34"
6 each side as above
SIDE STRINGER
Stringer Plate 12"x30"
Face Angle 3"x3"x30"
Shell " 3"x3"x30"
Sheerstrake 49"-46 to 28" in way of Ports.
Sheerstrake 43"-40" Doubling 19"x70"
Side Plating 30" to 26" Depth Moulded 19'11" at C.R.P.
Two Strakes increased 04 in. way of Engine & Boiler & Tunnel Recess in lieu of Side Stringer.
A B C

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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Thin paper copies	£3 3 0
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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS: "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8508 GERRARD.

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NOTICE.

Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase dates from and includes the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 188.

ENGINEERING.

FRIDAY, JANUARY 23, 1920.

NITROGEN PRODUCTS.

THE beating of a sword to a plough-share has never appeared an altogether promising commercial proposition. In its less metaphoric aspects the same problem too often has as little, or less, attraction, and to what one can profitably beat a few million 6-in. shell forgings it is difficult to say. It is curious that one important ingredient of our great output of war material—nitrogen compounds—should not only lend itself better than some others to a change from war to peace but should, from its use both for high explosives and in farming, add a new verisimilitude to Isaiah's metaphor. We do not know what the members of the Nitrogen Products Committee think of the matter, but it apparently should be some satisfaction to them to realise that the report of 350 odd pages which they have just issued is likely to be of equal value during war or after. The reference of this committee, which was appointed in June, 1916, covered consideration of methods for the fixation of atmospheric nitrogen from the points of view both of war and peace, but it is obvious that the committee owed its existence to the war and that the sword rather than the plough-share was in the minds of its creators.

The general question of the manufacture of nitrogen products can be looked at from several points of view. As an essential ingredient of modern explosives their production becomes a "key industry" in terms of the definition which the war has given to that expression. As a necessary link in the development of modern agriculture they hold a position second only in importance in war to that which they bear with reference to high explosives. The value of nitrogen products in this latter direction applies equally in peace with war, and those who take an interest in the advance of our agriculture may hold that the extension of their manufacture in this country should be assisted. In the use of "artificials" in farming we are far from occupying a leading position. The question of nitrogen products can again be looked at from the point of view of the extension of a valuable industry. In 1912 the world production of nitrogenous fertilisers was 4,084,483 metric tons, and of this total we produced only 394,521 metric tons in the form of ammonium sulphate. The world total given above includes Chile nitrate, which is a natural product, but it could be replaced by home manufactured compounds.

A preliminary consideration of the general question of nitrogen products causes it to appear one of much complication, but a closer study reduces it to simple terms. The apparent complexity arises from the number of different processes and the number of different compounds which are available, and which are competing as nitrogen fertilisers. One has Chile nitrate, a natural nitrate of soda of which there are vast deposits in Chile; ammonium sulphate, a by-product from the distillation of coal, and manufactured extensively in this and many other countries; nitrate of lime, produced by the arc process chiefly in Norway; calcium cyanamide or nitrolim, produced by treating ground calcium carbide with nitrogen at a high temperature and produced in the United States, Germany and other countries; ammonium sulphate produced by the Haber process, the commercial working of which has so far been confined to Germany; nitrate salts manufactured by the ammonia oxidation process which was developed to a remarkable extent in Germany during the war owing to the cutting-off of supplies of Chile nitrate. It is not necessary to extend this list further in this way. It is by no means complete, and mention might be made of the Häusser or explosion process of fixing atmospheric nitrogen, the Serpek or aluminium nitrate process, and the work that has been done in reference to nitrogen recovery from peat and sewage.

An enumeration of these various processes and products suggests a subject of much complexity, and from the point of view of the chemistry of the matter and the manufacturing processes entailed, the complexity certainly is there. Dealing with the subject broadly, however, and looking at it from the business man's point of view, it reduces itself to very simple terms. For actually at the present time there are but two branches of the nitrogen products industry which can be considered of great importance. These are the Chile nitrate trade and the manufacture of by-product ammonium sulphate. In 1912 the world consumption of Chile nitrate was 2,530,645 metric tons, and of ammonium sulphate 1,200,000 metric tons. Synthetic products of which calcium cyanamide and nitrate of lime were the more important, made up a total of only 150,000 metric tons. These figures are somewhat surprising. In view of the remarkable developments of Norwegian water power for the fixation of atmospheric nitrogen and the large amount of work which has been done in the United States and elsewhere towards the manufacture of calcium cyanamide, one would have expected that these competing products would have attained a more important position.

The figures we have quoted relate to a period some seven years ago; but there is no reason to suppose that the relative positions of the various industries materially altered just prior to or during the war. Output by certain of the lesser-known processes was advanced in Germany in view of the isolated position in which she found herself, but it is improbable that the quantities produced can seriously have affected the proportion of the figures we have given. As Chile nitrate has formed more than two-thirds of the world's total supply of combined nitrogen, it has controlled the price, which on the whole, during recent years, has shown an upward tendency. The manufacturers of competing synthetic nitrogen compounds have, however, been in a position to place their products on the market at a competitive price. This suggests that their manufacture is a sound business, and may ultimately become a very large one. Although the output is relatively small, it was increasing before the war at a much greater rate than the sale of Chile nitrate, or the manufacture of by-product ammonium sulphate.

The report of the Nitrogen Products Committee concerns itself in essence with the case for the establishment of plants for the fixation of nitrogen in this country. The report, as we have already indicated, is of great length, and much information, both of a statistical and technical nature relating to the various nitrogen processes is given. It would be quite impossible adequately to review the report in a single article, and some of the special problems with which it is concerned we will deal with on another occasion. The final recommendations of the committee may, however, be given attention here, as they necessarily must have important relation to the general world situation of the nitrogen products industries. The committee recommend that the calcium cyanamide process should be established in this country without delay, with Government assistance if necessary, and that the scale of manufacture should be sufficient to give an output of 60,000 tons of cyanamide a year. They also recommend that the synthetic ammonia (Haber) process should be established on a commercial scale forthwith in this country, and that a

minimum output of 10,000 tons of ammonia, equivalent to 40,000 tons of ammonium sulphate a year, should be aimed at. For this development it is recommended that the incomplete Government factory at Billingham-on-Tees, which was started early in 1918 for the manufacture of ammonium nitrate, should be taken over. In conjunction with this project it is recommended that an ammonia oxidation plant on a scale sufficient to produce 10,000 tons of 95 per cent. nitric acid a year should be completed.

It will be realised that these three proposals constitute a fairly ambitious programme, but they do not exhaust the enthusiasm of the committee. The remaining proposals are, however, likely to arouse less criticism. They cover encouragement of the by-product ammonia industry by facilitating the replacement of non-recovery coke ovens by ovens of the recovery type, and increase of the ammonium sulphate output by making it incumbent on all gasworks, which now contribute to the supply, to put into practice various expedients which have proved to result in considerable diminution in loss of ammonia by volatilisation and otherwise. A scheme for an increased recovery of by-products by the co-operation of the smaller gas works is also outlined. Finally, in this connection, it is recommended that the use of gas both for domestic purposes and for steam raising, in place of raw coal, should be encouraged as far as possible.

In addition to these, which may be called the commercial schemes of the committee, it is recommended that experimental work should be carried out on the Häusser process, the cyanide process, &c., and in general that the researches on the nitrogen problem initiated during the war should be continued. This matter of research we need not deal with for the moment. The proposals are likely to be generally acceptable. The recommendations in reference to the encouragement of, and improvement of efficiency in, the by-product ammonium sulphate industry are also likely, at least in broad terms, to be generally agreed with. This is an important industry in this country. In 1913 we produced 439,540 metric tons of ammonium sulphate, of which by far the largest part was exported. The material was obtained mainly from coke-oven plants and gas works. Clearly anything which can be done to improve the efficiency of an established industry of this kind is worthy of support, especially when the improvements take the form of the recovery of valuable material which is now wasted. The report states that as much as 25 per cent. of our coke was produced in non-recovery beehive ovens in 1917. In connection with gas works it is stated that there are very considerable variations in the results obtained, even among the principal gas works, and that very simple attention to certain points of detail would much improve the general position.

The recommendations of the committee in reference to the establishment on a large scale of various nitrogen fixation industries in this country open up a very different series of questions from those which follow on the recommendation in reference to by-product ammonium sulphate. The committee's arguments briefly are the necessity for rendering ourselves more free from dependence on imported nitrogen products and the value of meeting the increasing demands from home sources. In connection with the production of nitric acid for war purposes it is pointed out that prior to the war the arc process was the only alternative to the use of Chile nitrate. The development of the ammonia oxidation process during the war has, however, given an alternative supply of nitric acid. As this process requires much less power than the arc process, it is for this reason put forward as the most suitable for establishment in this country. This aspect of their recommendations may be in the main looked upon as a scheme for the inauguration of a key industry which is vital in war. The synthetic ammonia plant which it is recommended should be established at Billingham-on-Tees, may be considered as auxiliary of the ammonia oxidation plant, and would supply ammonia which would be available for conversion to nitric acid and ammonium nitrate by modern methods of catalytic oxidation.

It is interesting to note that the committee consider that the establishment of the ammonia oxidation process may ultimately lead to an abandonment of the older retort method of producing nitric acid from Chile nitrate. To say this is, of course, to take a long view. The proposed plant is to make 10,000 tons of nitric acid a year. Under pre-war conditions the manufacture of nitric acid in this country apparently amounted to a figure of about 14,000 tons a year. It will be clear that such a scheme as that outlined makes a very serious attempt to control the trade. The amount of Chile nitrate used for the manufacture of nitric and sulphuric acid in this country is, however, but a small proportion of the total production. None the less it must be realised that Chile nitrate is a raw material of the nitric acid industry, and any deliberate and Government-subsidised attempt to eliminate its importation is likely to meet with much opposition. Chile is a valuable consumer of manufactured materials, and it is doubtful if it is desirable, even if it is possible, to eliminate her importation of her important natural product. The necessity for safety in war might, however, over-rule other considerations.

The other main recommendation of the committee—that for the establishment of a large calcium cyanamide plant—rests its claims rather on the needs of agriculture in war, the expanding market and the value of the industry, than on any question of munitions. It is incidentally suggested that one of the proposed water-power schemes in Scotland should be utilised in connection with the proposal. If the report causes any manufacturer or group of manufacturers to take up this matter seriously it will have done good work. The establishment of the industry is probably indeed worthy of Government aid, but that the manufacture of purely commercial products like calcium cyanamide and calcium carbide should be undertaken by the State would be very objectionable. The thing could be done, but instead of a profit being made we should expect one further slight burden on private industry in the shape of a subsidy to carry the thing on.

BOILER EXPLOSION INQUIRIES.

MR. WELLS has acutely observed that the lawyer and the politician are likely to remain our masters till the end of time, and an interesting instance of the difficulty of preventing the lawyer from assuming position and powers for which he has no qualifications is brought forward by Mr. C. E. Stromeyer, in his latest report to the Manchester Steam Users' Association. This association was directly responsible for the Boiler Explosions Act of 1882, and the principal object in view at the time was the improvement of practice, by providing that every explosion should be investigated by an expert. In order to get the Bill through Parliament, however, it was unfortunately found necessary to "placate" the lawyers by the provision that each commission of inquiry should comprise in addition to engineering experts, "one competent lawyer." The result has been that this lawyer is always made president of the commission, and the evil does not end here, since he not unfrequently abuses this position, to object, often successfully, to any questions being asked by his engineering colleagues. The natural result has been that in a large number of cases the report finally issued has been much less instructive than it should have been, and in many instances it has been distinctly misleading.

Lawyers are commonly credited with "a judicial temperament," but the real nature of this qualification is in general totally misunderstood. It does not (though the contrary is frequently asserted, imply any special capacity for weighing evidence) but merely the quality of listening without signs of impatience to the presentation of both sides of a question, no matter how foolish one of them may be, both in method of exposition and in fact. So far as human testimony is concerned, the quality has undoubtedly its advantages. An ignorant inventor of a perpetual motion, for instance, can rely on what he would consider "a fair hearing" from a suitably paid lawyer, whilst a self-respecting engineer would dismiss him out of hand. It does not follow, in any way, that this "suffering of fools gladly" is necessarily associated with any real capacity for weighing evidence. Instances to the contrary could be cited amongst present occupants of the judicial bench; but it will be more prudent to recall the case of the famous Sir Matthew Hale, a most eminent judge of the seventeenth century, who is recorded as being remarkable in those troublous times for holding himself aloof from prejudice and partisanship and to have discharged his duties with resolute independence and diligence. He had, in fact, an eminently judicial temperament, but his competence as a judge of evidence may be gathered from the following quotation from his observations at a trial at which he condemned two women to be hung for witchcraft. He maintained that the reality of witchcraft was incontestible "for first the scriptures had affirmed so much and secondly the wisdom of all nations had provided laws against such persons."

It is pretty evident from the foregoing that the judicial temperament constitutes by itself but a poor qualification for a commissioner appointed to conduct scientific or technical inquiries. As is very natural, the barrister, who acts as president of a boiler inquiry commission, tries to divert, so far as is possible, the course of the proceedings, from technology of which he knows nothing to law in which he is expert. He aims accordingly at establishing a legal responsibility on those connected in various capacities with the boiler under review, rather than at the advancement of knowledge by providing data by which engineers may amend faulty practice. No doubt the course adopted does tend indirectly to improve practice, since the knowledge that any one connected with a boiler is liable to heavy fines should failure occur, does induce greater care in boiler management. Indeed, this remains true even if the penalty is not always justly imposed. The maxim of the "debilitated cousin" in "Bleak House" that it was "far better hang some fler than no fler," immoral as it may be, has been proved effective by rulers from the Rome of antiquity to the Bolshevist of to-day. Both adopted the practice of taking hostages and neither of these different forms of despotism has shown any hesitation in executing the "wrong fler" when the right one was unattainable.

It is not, however, a practice which commends itself to the instinct of fair play, and Mr. Stromeyer is fully justified in drawing attention to the fact that under their present direction these commissions of inquiry are more akin to the inquisitorial Continental courts with their *juges d'instruction*, than to the British pattern. The witnesses, he states, have no legal protection, and may be heavily fined on their own evidence. Hence they are naturally very guarded in their statements, and data which might prove very valuable as a guide to future practice may be entirely suppressed, and most of the reports, of which over one-half are prepared by the lawyers concerned, make no mention of essential technical points. Thus, in numerous cases, the thickness of the shell plating of the exploded vessel is not mentioned, and there is, accordingly, no possibility of estimating the stress at failure, and no guidance as to whether the factors of safety in common use are in accordance with experience. Again, the preliminary inquiries are held by the Board of Trade surveyors, appointed apparently in rotation, instead of being confined to two or three men who would rapidly become experts in such matters.

It follows accordingly that the reports published are far less instructive than they should be, and hence those interested in them have to dispose of "an intolerable deal of sack" in the way of irrelevant detail in order to attain to even a poor "halfpenny-worth of bread" in the form of useful technical data. Fortunately, however, the task of digesting these reports and extracting from them such matter of value as they may contain, has been undertaken by Mr. C. E. Stromeyer in the surveys which he presents annually to the Manchester Steam Users' Association. Thus a very valuable discussion of reported failures due to "Water Hammer in Steam Pipes," which will be found in the report for the year 1908; another "On the Strength of Stayed Flat Plates" appeared in his report of 1912; whilst the report just issued contains a valuable discussion of the safety of cast-iron economisers. Whilst destructive explosions of economiser pipes are

relatively rare it appears from the data collected by Mr. Stromeyer that failures are fairly frequent, and that on the average one pipe in an economiser will require replacement every five years. Only about one in 2,000 of these failures is, however, accompanied by an explosion. Why there should be failures is far from obvious. The stress is very steady and the factor of safety reckoned in the ordinary way is from 20 to 30. Yet, whilst steam-engine cylinders subjected to varying stresses of less intensity hardly ever fail, there are unreported failures of economiser pipes almost daily.

Occasionally the failure takes the form of a disastrous explosion, although the safety valve area provided is ample according to all accepted rules of design. This, Mr. Stromeyer attributes to the fact that a pipe failure which ordinarily involves no danger, chances on occasion to coincide with an error on the part of the stoker in control of the plant. At times, in fact, the stoker forgets to close the damper when the feed is shut off. The consequence is that the tube becomes a steam generator, and should it fracture in this condition the elastic force of the steam may turn the fragments into dangerous projectiles. So far, however, Mr. Stromeyer is unable to proffer any explanation as to why these pipes should fracture, but the subject is obviously one worthy of expert inquiry, which would no doubt have been made ere this had the Boiler Explosions Act been interpreted and worked along the lines contemplated by its original promoters.

WATER-COOLING FOR TURBO-ALTERNATORS.

THE electrical engineer from the nature of his craft is forced to the extensive use of materials which the designer of machinery in general is very glad to be free from. This in a sense has always been a handicap to the electrical designer, although in view of the position to which the electrical industry has now attained it may be held that he has met that handicap in a very able way. There is much truth in this, and good mechanical design has certainly assisted electricity in living up to the claims which it is able to make in so many important industries. Even now, however, electrical machinery has not quite been able to draw level with purely mechanical machinery in some lines of work, and it still carries something of the stigma of the day of sealing-wax and bent wire. The most prominent example of the persistence of this feeling is now furnished by some of the opposition to its use in connection with the propelling machinery of ships. Part of the opposition is due to genuine technical opinion that electricity has not made its case as a ship-propelling agent, but other is certainly due to a still persistent idea that electrical machinery is unmechanical.

Any outsider who heard Mr. Shepherd's paper read before the Institution of Electrical Engineers, on the 8th inst., or who read the reprinted paper in our columns during the last two weeks, might be pardoned for thinking that distrust of electrical machinery by the mechanical engineer is well founded. The first half of Mr. Shepherd's paper might well give the idea that a modern power-house is of pyrotechnic rather than of mechanical interest. We do not think Mr. Shepherd was to be blamed for this. A paper which deliberately deals with failures of turbo-alternators and gathers a record of many remote happenings into one place, of necessity may appear to lay undue stress on such failures. It would have been well if Mr. Shepherd, or some speaker in the discussion which followed the reading of his paper, could have given some quantitive idea of the relative and absolute importance of the causes of breakdown with which he dealt. The position which the high-speed alternator now holds in industry sufficiently disproves any idea that it is not a thoroughly sound and reliable machine. In so far, however, as Mr. Shepherd's paper was a consideration of mechanical details in the construction of turbo-alternators and in so much as it was a plea that the mechanical aspects of the matter should never be lost to attention, it has all our support.

We have already said that the false idea of the unreliability of the high-speed alternator which might be gathered from a consideration of Mr. Shepherd's paper by an outsider was due probably rather to the cumulative effects of a recital of breakdowns than to any intention on the author's part. Unfortunately, however, Mr. Shepherd's collected evidence appears to have so impressed himself that he has joined the ranks of his own converts and he, too, appears to think that the modern alternator is so little to be relied on that it is in need of drastic re-designing. Another explanation of Mr. Shepherd's opinion may be, of course, that he has had more than his due proportion of breakdowns. This is very possible. In any widely distributed experience there will always be some people who have bad luck and some who have good. If 1,000,000 people toss for half-pennies, 500,000 will lose in the first round. If they toss again, then by all the laws of probability about half of the 500,000 will lose again. If they toss a third time, about 125,000 will prove to have lost three times, and so on. After a dozen tossings, some wretched men will have lost 12 times. They will call it bad luck, but on no known doctrine of averages could they have won. Mr. Shepherd, we must assume, is one of these wretched men, and more than his share of breakdowns have come to his stations.

Although we believe Mr. Shepherd's picture of the modern alternator contained far too much black paint, this is no reason why his proposals for a reformed alternator should not be given consideration. His suggestion briefly is that water-cooling should be substituted for air-cooling. The first obvious comment on this is that it is going to complicate the machine. This in itself would not necessarily condemn the proposal, but it is none the less progress in the wrong direction. An added complication must be able to make a very good case for itself before it can be accepted. This applies we think, especially to electrical machinery. An alternator, considered mechanically, is a very simple device, and it is probable that on that simplicity much of its success rests. Some of the materials which necessarily go to its making are of such quaint properties from a mechanical point of view that it is to be feared they might fail altogether in a more complicated type of mechanism. No one would like to have much mica or shellac in the composition of, say, an automatic capstan lathe.

The added complexity which water-cooling would bring to the turbo-alternator could only be tolerated if it could be shown to carry important advantages. The claims made by Mr. Shepherd for his proposed cooling system cover a smaller diameter of rotor with consequent reduced centrifugal stresses, a lower working temperature with less fire risk and longer life and, particularly in the stator, an adjustment of the amount of cooling in every portion of the winding, with a consequent elimination of hot-spots. Of these claims we think that of longer life is the only one which can be considered to carry any important weight. The existing air-cooled alternator is a working commercial article, and we do not think any of these claims for its proposed competitor carry sufficient promise of improvement to constitute a serious attack. The question of life is, however, an important one. There is apparently nothing in an alternator to wear out except the bearings, and these apart there is nothing in the appearance of it to suggest that it might not run for ever. The gradual perishing of the insulation under mechanical stress and raised temperature is, however, an important consideration in the life of the machine. Mr. Shepherd proposes to eliminate one of the weak mechanical points of the insulation of the rotor winding by carrying the end windings in slots. This might be of value, but it is not necessarily to be associated only with water-cooling. The question of temperature is a different matter, however, and one of Mr. Shepherd's best points is that his water cooling might prolong the life of the insulation.

Another of what appears to us to be Mr. Shepherd's best points he failed specifically to make for himself. This is that the lower temperatures resulting from water-cooling should enable considerably more power to be obtained from a water-cooled machine than from a corresponding air-cooled one. This effect might conceivably swamp the extra cost of the water-cooling installation. Another point Mr. Shepherd made was that in certain situations suitable cooling air was difficult to obtain. This applied to the tropics where the air was hot; to high altitudes where the air density was low; to shipboard where the air was salty and to special situations where the air was dirty or sulphurous. These are fair points, and if water-cooling develops we should expect to see its early application to such special cases. For the present we do not anticipate that it will be seriously considered for normal working. It is perhaps unfortunate for Mr. Shepherd that so many of the important electric power installations of the world are situated in countries which are cold in the winter. This normally is the time of greatest load so that for a very large proportion of users the air is cold just when it is so wanted. This makes the present air-cooling system for alternators most efficient just when it is of greatest importance.

It will be gathered from what we have already said that we do not consider the development of the water-cooled alternator a matter either of urgency or of immediate probability, at least as far as normal service is concerned. This is not to say, however, that in some situations it might not have advantages, and it is possible that experience gained in such situations might lead to its more general development. That the problem of its design will be a difficult one, however, is well illustrated by Mr. Shepherd's paper. After describing his proposed arrangements, Mr. Shepherd says "consequently, combining skilful design, stout construction and reliable workmanship, one can ensure no movement of the coils, no leakage of the water devices, and no overheating of the coils." This is no doubt true, but surely it is well to realise that these admirable qualifications applied to an air-cooled alternator will lead to corresponding excellent results. We remember Sir Horace Darwin, we think it was, referring to an instrument which had been described to him and of which the design was so excellent that enormously accurate work was necessary in its manufacture if it was to operate at all. It was very properly pointed out by Sir Horace that such a condition was indicative of a bad design, not a good one. It is the same with Mr. Shepherd's alternator. If it is to demand any remarkable and exceptional quality of workmanship to make it a satisfactory article then the design is not good, it is bad.

In this connection we think Mr. Shepherd is too fond of what he terms fusion welding. In reference to it he makes the remarkable statement that "fusion welding is now an accepted construction for the more arduous requirements of high-pressure boilers and steam piping." The only possible reply to this statement is that it is not true. In virtue of this belief, however, Mr. Shepherd proposes to use welding to a considerable extent in his alternator. For instance, for cooling his rotor winding, he forms the rotor stamping with slots in the teeth between the winding slots. When the stampings are built together these slots form a water passage, and it is closed by welding a strip of metal along its open side. Incidentally this procedure connects the rotor stamping together magnetically, but, more serious as it appears to us, a narrow slot is formed which can never be cleaned out properly or got at. Another point is that sooner or later, and in some installation, water would probably find its way between the laminations. We are aware that skilful design, stout construction, &c., would prevent this, but Mr. Shepherd's alternators, if they are to be made at all, will have to be made in an imperfect world. The whole idea of small water passages which can never be either cleaned, or inspected, is not very attractive, and we fear Mr. Shepherd's design is in some of its aspects chiefly of value as illustrating the difficulty of the subject he is tackling. It is not necessary to pursue this subject further at the moment, but in conclusion one may raise the question of the effect on the alternator of a stoppage of the water circulation. Water circulations sometimes do stop in practice.

LONDON TRAVEL.

LORD ASHFIELD (the title taken as a Peer by Sir Albert Stanley), speaking at the American Luncheon Club on Friday last, told a story very different from that we used to have drummed into our heads some years ago. Then we were constantly

told how low the journeys were in London per head, and how far we were outdone by New York in this respect. Now we are informed that London is the greatest riding city and the fastest travelling city in the world. For the change we have to thank very largely Lord Ashfield and his predecessor, Sir George Gibb, who have taught us to appreciate the value of co-ordinated service. We have indeed learnt our lesson well, but let us beware lest the enthusiasm of these traffic experts leads us to overdo things.

Lord Ashfield tells us that the provision of facilities provokes new habits of travelling. This is a well-known maxim in railway circles, but do we want our lives mainly to be regulated for the benefit of transport systems? Supposing we could on some scale plot facilities against journeys per head, the resulting curve would be one of increasing slope. In the ultimate the curve would go off to infinity, when we would become reduced to the restlessness of the molecules of physics. We cannot regard this as an altogether pleasant consummation, however much satisfaction the contemplation of such an achievement might bring to Lord Ashfield and his staff. We have no desire to arrive at a stage of incessant movement, at speeds vastly greater than those common to-day, at any rate until the human frame has undergone substantial change. We run the risk of being exploited by experts "ever reaping something new: That which they have done but earnest of the things that they shall do." Let us rather see that our traffic men live for us, instead of we for their justification.

Suppose instead of following our facility curve to infinity we are heretical enough to trace it backwards, we come inevitably to the conclusion that as facilities decrease travelling gradually becomes curtailed. In the limit, with no facilities there would be no travel, except pedestrian. Then people would remain where they lived, and would have to earn their living in the neighbourhood. Thus we come to the idea of "towns of the outer circle" of which we have heard something lately. The activities of such men as Lord Ashfield would then have to find some other outlet. Possibly they would turn their attention to the interchange of things instead of persons.

Lord Ashfield says that in these matters we want men of vision and imagination. "Your young men shall see visions; your old men shall dream dreams." Lord Ashfield falls, of course, in the former category, and has the advantage of possibly living long enough to see some of his ideas realised—or his views changed. The visions of men vary with their point of perspective. The writer of the Apocalypse had visions of a city with streets of pure gold, as it were transparent glass, which now seem immeasurably distant, with gold so scarce that its existence is apt to be forgotten. The material side of Sir Thomas More's vision of Utopia was laid on a less splendid scale. In his fair cities he was satisfied with streets only 20 ft. wide, which he considered "very commodious and handsome." Lord Ashfield, whose very existence must be justified by an increase of traffic on our streets and railways, has now also "dipt into the future far as human eye can see" and seen "the vision of the world, and all the wonder that would be." His mind runs on a rapidly-increasing number of underground railways and vast underground roads for motor traffic. If we asked an engineer interested in aeronautics what his views might be he would probably refer us to Tennyson's "pilots of the purple twilight." And so on.

Let us by all means have men of vision and imagination, and let them also have courage to break away if possible from the present trend. After all, more railways and underground roads, are little else than developments of our present system, and realisable only at constantly greater expense. Tube railways are notoriously expensive to build, and, with the network now existing still further complicated, the depth would have to be greatly increased for additional services. The same applies to underground motor roads which would in consequence require impracticably lengthy approaches.

Can we not do something better than this? Would it not lead to healthier living if we could get our men of vision and imagination, not to concentrate so much on getting more and still more traffic into and through central London, but to tackle the radical problem of whether this huge concentration during business hours cannot be improved upon. As it is, there is an enormous amount of quite unnecessary traffic. Many of the shops could equally well be situated in the outskirts. People can buy their tobacco or ties just as easily before catching their morning train as after arrival at their city destination. Every shop in London means assistants, amounting to thousands in the case of big stores, crowding trains already overtaxed, and, in addition, a good many journeys especially undertaken by purchasers. All these might be saved. If the work were situated in the outer circles, the concentrated crowds of to-day would cease. We would not need to weary the human frame with a long and uncomfortable journey before and after the completion of our business. Our sports would be nearer hand and, having done our tasks, we could turn to our relaxation more quickly and with a less exhausted body. Here is a fertile field for our men of vision. Mere developments will no longer serve us. Something more basic is wanted to provide relief. The ever and ever-growing daily concentration, whether, as now, a condition of unrelieved discomfort, or rendered by the continued effort of men like Lord Ashfield, comfortably feasible, is not the best solution for a healthy metropolis. Why not grasp the problem firmly and see if something cannot be done to reverse the present tendency. Instead of everybody rushing "up to town" and leaving the outskirts all day to the children and housekeepers, the better thing would be for people to have their work brought nearer to them. Then it would not matter to how great an extent London expanded, whereas now we are fast reaching conditions verging on the impracticable. "The clock beats out the little lives of men," and to each man only one. Let it be ours to see that in the future, if possible, they are passed in better conditions. The time now spent in getting to and from work is so much sheer waste out of a lifetime. The traffic people are making laudable attempts to reduce it to a minimum, so far as in them lies. How much better it would be if we could to a substantial extent make the loss unnecessary.

LOW-TEMPERATURE STUDIES.

WITH the new session of Friday discourses, which were opened last week on January 16, the Royal Institution returned to the pre-war hour of 9 p.m. During the war the Friday discourses had commenced at 5.30 p.m. As in many previous sessions, Sir James Dewar, F.R.S., delivered the first discourse. Introducing his subject, Sir James remarked that, when he had commemorated the Coming of Age of the Vacuum Flask, in his discourse of January, 1914, he had hoped soon to report on further progress in that field—in which Sir James naturally retains a personal interest. All that hope had gone during the last few years; the difficulties of the general position had become too great, the cost of low-temperature research was five times what it had been, and he would have to limit himself to special aspects of low-temperature research in his discourse.

The first experiment shown by Professor Dewar characterised his particular subject. A spherical bulb of glass, filled with liquid oxygen, was placed in front of the lantern serving as lens for the arc-light beam; a piece of black paper was held near the focus of the lens; the paper almost immediately began to smoke, showing that the heat rays were not stopped by the liquid oxygen, in spite of its low temperature of —190 deg. C., as was indeed to be expected. When a thin membrane of india-rubber was interposed between the bulb and the paper, the paper was still burnt. Thus both the liquid oxygen and the thin membrane were permeable to the arc rays, and, as the subsequent demonstrations proved, also to dark heat rays. The effect of cold on rubber was known to be peculiar; rubber contracted when heated, and expanded when cooled. Professor Dewar demonstrated this by an old experiment of his. He had a rubber balloon filled with water; when the balloon was pricked with a sharp needle, the pressure of the stretched rubber forced the water out in a fountain. When hot water was poured on the balloon, the fountain rose higher, because the rubber contracted. That contraction would, under ordinary conditions, distort a stretched membrane and make it pucker. If cooled slowly and uniformly, however, a thin membrane would practically remain plane, and such a membrane might be utilised in a thermoscope within liquid air. The behaviour of these membranes had first to be studied, however. Examining the distortion effects caused by placing loads on very thin membranes, Sir James showed, with the aid of a U-tube pressure gauge, that membranes cooled with liquid air were only distorted half as much as when at ordinary temperature. The curves exhibited proved that the distortion increased regularly with the load both at + 11 deg. C. and —190 deg., but was much smaller in the latter case; for his purposes, Professor Dewar said, a distortion of 0·001-inch would spoil a membrane. Thus the cold made the membranes stronger and further impermeable to gas. A thin membrane, which allowed air to diffuse through into a vacuum on its other side at the rate of 2 cub. cm. per sq. cm. per day at ordinary temperature, would not allow 1/10,000 of that amount to percolate at the temperature of liquid air, and in liquid hydrogen the membrane was practically gas tight. But membranes might work splendidly for days and weeks and then fail. In the thermometer to be described, however, charcoal was the real material, and the membrane served only as part of the devices indicating the gas pressure.

Charcoal had the valuable property that it adsorbed gases at all temperatures and liberated them again when heated; the gas pressure would then rise, and that was the thermometer effect utilised. To make the effect strictly reversible, the charcoal should be saturated at constant pressure. It was further necessary to have one pure gas, because charcoal would adsorb mixed gases, but would not liberate the constituent gases in the same proportion. Thus, when charcoal was saturated with air and then heated, the gas liberated was stronger in oxygen than the gas adsorbed. When the charcoal was charged with oxygen, and then exposed to a current of hydrogen, the liberated gas would contain both the elements, and if the first gas were nitrogen (instead of oxygen) the preponderance of hydrogen in the liberated gas would be very marked.

The new thermoscope, which Professor Dewar then described, was a vertical tubular vessel filled partly with liquid oxygen, in which a small mass of charcoal was kept in a cell, which was covered by the membrane. The top of the membrane was exposed to the radiation to be investigated coming from above, when a metal lid or trap-door, resting on the ring mounting of the membrane, was lifted by means of a small chain from outside. There would be about 5 cm. of liquid air above the cell, and the radiation had first to penetrate through this oxygen and the membrane before it reached the charcoal; a metal tube of small diameter connected the cell with the U-pressure gauge outside. The gas adsorbed by the charcoal was oxygen, and that oxygen had to be pure. The tubular vessel in which the oxygen was contained was provided with a vacuum jacket, and was itself suspended in another vacuum-jacketed tube charged with liquid air. The radiation to be tested passed down the upper portion of the oxygen tube, which contained only oxygen vapour and was lined inside with black paper in order to avoid any scattering of the radiation by reflection. The liquid oxygen must be clean, *i.e.*, free of dust, of ice crystals (moisture) and of carbon-dioxide snow for the same reason. To effect this cleaning, the oxygen was stirred with a quartz rod which became highly charged electrically at the low temperature; a crystal of uranium nitrate could be used for the same purpose.

The membrane itself was very fine; it was stretched over the cell wall, a brass ring, about 4 cm. in diameter. The middle of the cell was taken up by less than one gramme of charcoal, which was supported on a piece of chiffon (silk gauze) out of contact with the brass ring. The charcoal surface was about 1 sq. in. Above the membrane the cell ring supported a stage of sheet metal, provided with a central aperture. The body to be examined was

placed on this stage, and was protracted by the trap door mentioned, until the door was raised. It will be understood that the specimen, as well as the whole cell, would generally be immersed in liquid oxygen, and the transmission of heat rays through various thicknesses of liquid gases had hence to be studied. Some experiments were also made with the cell in the gas above the liquid, but Professor Dewar's curves showed that, though the rise of gas pressures was much greater when the whole cell was entirely in the gas, it took a longer time—several minutes—to establish equilibrium conditions, whilst some of the experiments conducted with the cell quite submerged occupied 20 seconds only.

The slides shown proved that the pressure of the liberated gas rose, in gases and liquids at different temperatures, with time in regular curves, rapidly at first, then slowly, and descended again rapidly at first on shutting off the radiation. The sensitiveness of the method was extraordinary. Temperature changes of half a thousandth of a degree Cent. could be detected by this method. Working in his laboratory at a uniform, rather low temperature, Sir James found that when the door was raised, the heat of the room caused his manometer to rise by about 3 cm. When, in the course of the lecture, he brought a Leslie cube containing steam near his novel thermometer, the dark heat rays from the black surface of the cube sent the manometer up three times as high; the polished side of the cube produced a very much smaller rise.

The radiated energy to which these effects were due increased according to Stefan's law with the fourth power of the temperature. Exhibiting the curves of Lummer and Pringsheim and others exemplifying the distribution of the energy of radiation in the spectrum, Sir James pointed out that at —80 deg. C. the curve was flat, and extended all over the spectrum with a hardly-pronounced peak near 15 μ, while with higher temperatures the curves became much more peaked, and the peaks shifted more and more over into the ultra-violet. When, however, a specimen, say a quartz plate, was placed on the stage in order to see how much of the radiated energy passed through the specimen, another effect had to be considered: part of the rays would at once be reflected by the surfaces of the specimen, so that the energy transmitted through the specimen (at the low temperature of liquid oxygen) could not be calculated directly on the amount of energy emitted by the source of heat. Now according to Fresnel's law, the reflection at a plane surface increased as the refractive index of the substance increased, though there was proportionality between the two effects. Studying these relations and plotting the percentage of reflected energy as ordinate against the refractive index as abscissa Sir James obtained similar curves for ordinary air and liquid oxygen, but the reflection was much smaller in the denser, more refractive liquid than in the gas.

Coming to his results Sir James rapidly exhibited a series of slides exemplifying the amount of radiations, of different temperatures, which were transmitted through various materials, including a large number of organic compounds, when examined in liquid air. Every material was, of course, transparent if of sufficently small thickness. But water was comparatively opaque to dark rays, and celluloid likewise, whilst collodion films and soap bubbles were perfectly transparent, more than air. Materials like quartz, glass, rock salt, were studied in plates of various thickness or powdered and compressed; compounds like silver chloride were rolled out in sheets; organic compounds were studied in the frozen condition or as films between thin plates. The source of heat was a kind of Leslie cube—in order to make the radiation as black as possible. With respect to this point Sir James had other curves to show — containing materials at temperatures ranging from —80 deg. C. (solid carbon dioxide snow) up to +100 deg. C. and higher. In the case of rock salt the following results were obtained, the percentages indicating the amount of radiation transmitted by the substance at temperatures of liquid air: polished, thickness 2 mm. or 0·5 mm., 90 per cent.; ground fine, then compressed at 50 tons per square inch, 70 per cent.; the same, moistened with brine, 30 per cent.; precipitated with alcohol to obtain very fine particles, which were dried and compressed, 51 per cent.; the same moistened with brine, 18 per cent. Under conditions when water (ice) was quite opaque, dry hydrochloric acid transmitted 10·6 per cent. of the radiation received, sulphur dioxide 20 per cent., ammonia 4 per cent., methylammonium 8 per cent. (ethylammonium was much more transparent), carbon tetrachloride 33 per cent., carbon oxy-chloride COS, 53 per cent., phosphorus 76 per cent. These figures were uncorrected for losses by reflection. In the case of iodine, which was a good reflector, the transmission observed was 38 per cent.; corrected for reflection it amounted to 63 per cent. The hydrocarbons pentane, hexane, decane, &c., transmitted the heat well (40 per cent. to 80 per cent.); naphthalene transmitted only 19 per cent., camphor 9 per cent., benzene 49 per cent.; nitrogen compounds, pryidine, quinoline, &c., gave in general low values, and the substitution of hydrogen by nitrogen radicles generally lowered the values in organic compound, whilst the introduction of chlorine tended to raise them. Even ammonium salts like the bromide differed in this respect strongly from alkali salts like rock salt. Isomeric organic compounds showed very marked differences in their transmission of dark heat rays. As regards the silver halides it was interesting that increasing thickness of the plate little affected the high values: AgCl gave 84 per cent. transmission for 1 mm. and 85 per cent. for 0·15 mm. plates; AgB r of 0·6 mm. or 0·1 mm. gave 82·5 per cent. and 86 per cent. Mr. W. J. Green, B.Sc., and Mr. J. Heath assisted in the demonstrations.

In his concluding words Sir James referred to the origin of the Friday discourses, about which he had been asked. They had been introduced by Sir Joseph Banks, for many years president of the Royal Society, who had allowed members of the Royal Institution to attend in the Royal Society on those occasions. In the Royal Institution Faraday had inaugurated the discourses in 1826 with a lecture on caoutchouc and rubber, a subject cognate to that of his own discourse, Sir James Dewar remarked, and Faraday had then stated that the discourses should be: interesting, amusing, and instructive, the lecturer dealing with scientific research and abstract reasoning in a popular way, with dignity, to attract the world and making himself attractive to it.

THE POLICY OF THE MINISTRY OF TRANSPORT.

OCCASIONALLY there is a slight pulling aside of the curtain hiding the policy of the Ministry of Transport, now being formulated by Sir Eric Geddes and his coadjutors as a consequence of the passing of the Transport Act. At Cambridge, on Tuesday, Sir Eric gave some suggestion of his views regarding competition, which must be read in the light of the question of possible nationalisation. His view was that amalgamation territorially was right, but amalgamation for inter-system competition was wrong. In other words, wholesale competition between companies with the same traffic without any creative interest between lines was wrong. This led to favouritism, special discrimination, costly working, unremunerative labour and capital expenditure, and, while favoured consigners gained, others paid. The idea rather was that the railways should compete in developing the districts they served rather than in trying to filch traffic from each other. In order to obviate amalgamations becoming oppressive, and to prevent the absence of competition unduly curtailing facilities, there was need for a reviewing authority with power to order adequate and reasonable services and conveniences. Obviously the Ministry of Transport would constitute such a reviewing authority.

Sir Philip Nash, who is Director of Railways at the Ministry, has also been putting forward views on some of the working problems of the railways, and, regard being had to his position, these views must be accepted as indicative, at least, of the line of thought of the Ministry. His observations were confined to three important developments. The first had reference to terminals, not only in towns but at ports, and he very properly pointed out that there was great need for a large increase in handling machinery; he preferred, for diplomatic reasons, to call it labour-aiding rather than labour-saving. We have, in ENGINEERING, illustrated developments in this direction made notably at the Lancashire and Yorkshire port of Grimsby and at one of their distributing centres in Manchester, and, in view of the cost of labour, financial advantage must accrue from such developments, apart altogether from their influence in overcoming the present congestion and on the railways holding-up of wagons. The second point raised by Sir Philip had reference to the necessity for increased capacity of wagons, the gain from which is self-evident, especially in connection with mineral traffic. The third point was the desirability of electrifying the lines. The whole of the electric system of the country has been passed from the Board of Trade to the Ministry of Transport, so that Sir Eric Geddes and his staff will now be able to accumulate data in order to formulate their policy.

The occasion of Sir Philip Nash's speech was the dinner of the past and present Crewe men, held on Friday, the 16th inst., and Sir John A. F. Aspinall, the consulting mechanical engineer to the Ministry, who presided, expressed his complete concurrence with the view that electrification for suburban traffic must confer great advantage, but was inclined to the opinion that the case had not been made out so clearly for the long-distance trains. Mr. H. N. Gresley, of the Great Northern Railway, was much more decided in this latter view, and thought that the highest degree of efficiency and power in the steam locomotive had not yet been reached. The difficulty, he contended, was with the load admissible per axle—owing to the strength of permanent-way and bridges. In America 30 tons was allowed per axle, and if this could be reached, or even approximated to, in this country the steam locomotive could be made enormously more powerful. Another difficulty, we may add, is the limits of the loading gauge, also a question for the civil engineer. Mr. C. J. Bowen Cooke, of the London and North-Western, added one more item connected with the policy of the Ministry in contending in favour of the professional side of railway undertakings receiving more consideration at the hands of the Government when they were revising the rates of remuneration of the *personnel* of the system.

We may add that the dinner was a great success, 110 members being present, and one interesting incident was the presentation to Mr. A. H. Hernu, who for thirty-seven years had been honorary organiser. He is now succeeded by Captain Reginald Terrell, M.P.; who is to be congratulated on Friday's function. In his speech he strongly accentuated the importance of *esprit de corps* in developing efficiency, and incidentally also added one note with reference to the transport policy. The Joint Advisory Committee which the Government has set up in connection with the railways has not a single locomotive engineer on it: this is surely an omission which ought to be remedied.

NOTES.

THE SPELTER SITUATION.

In 1913 the spelter produced in the world amounted to about 982,000 tons, the United States having produced 32 per cent. of this quantity and Germany 28 per cent. While we produced only 6 per cent. we consumed no less than 23 per cent. of the world's production. In 1919, according to the Journal of the Society of Chemical Industry, the world's production was only about 520,000 tons. Of this the United States had produced 410,000 tons, while our share had only amounted to 20,000 tons, the output being limited by shortage of ore, and labour troubles. In the last year we had to import over 94,000 tons, and unless more plants are erected we shall continue to be dependent on foreign production. The price is now about twice what it was in 1914. As regards treatment of the ores the flotation process has practically superseded electromagnetic separation, and finer crushing is in consequence in vogue. Electrolytic precipitation has not met with much success, though it has been adopted for new plants in Tasmania, Canada and the United States, in every case cheap power being available. Electric furnace reduction has made

good progress in Norway, Sweden and France, where cheap power is available. Mechanical furnaces are replacing hand-rabbled furnaces with good results, both as regards labour costs and coal consumption, while the more even supply of the sulphur fumes is found an advantage in the working of the sulphuric acid plants. It is stated that whereas before the war from 14 tons to 15 tons of coal were needed to reduce 10 tons of ore, in a modern plant the same amount of work can be accomplished with 8 tons of coal. The furnaces in this case were built with counter-current recuperators without reversing valves. Weighing, mixing, transportation of the charge to the furnaces, charging, &c., are all now done by machinery. With machine charging the operation is reduced by about 2 hours compared with the old system. The review of the situation concludes that the industry can be carried on profitably in Great Britain provided modern methods and machines are adopted, and that there need not be any fear that there will be no market for the product.

The Liverpool Section of the Institution of Electrical Engineers.

The inaugural meeting of the Liverpool Subcentre of the Institution of Electrical Engineers was held on Monday evening last, in one of the lecture theatres of Liverpool University. The chairman of the new sub-centre, Professor E. W. Marchant, presided, and delivered an address, in which he stated that it had been found that Manchester, the headquarters of North-West Centre, was somewhat too far from Liverpool to make it convenient for members residing in the latter area to attend the meetings of the society, and hence it became desirable to organise a local sub-centre. Liverpool, he pointed out, possessed one of the largest factories in the country for the manufacture of telegraph and telephone instruments, its shipping gave it a special interest in wireless telegraphy and important cable-making and electrochemical industries were developed in its neighbourhood. With respect to the latter he said that one of the principal undertakings had originally installed a number of large gas engines of German make for generating the current they required. In subsequent additions to the plant, however, steam turbo-generators have been installed, although the load factor being nearly 100 per cent. enabled the most to be made of the high thermodynamic efficiency of the internal-combustion engine. The reason given is that the turbines require much less labour, and the saving in this respect was sufficient to offset the higher fuel economy of the gas engines. Professor Marchant also drew attention to the great number of students which, since the conclusion of the war, have crowded the class rooms of our technical colleges, and recalled the fears that have at times been expressed as to the possibility of absorbing in the engineering undertakings of the country such large numbers of trained men. So far as electrical engineering is concerned, the speaker was confident that such fears were unfounded, since he believed that the next few years would see an enormous increase in the development and use of electrical power, both at home and abroad. He suggested, further, that many might be attracted to the commercial side of engineering work, which would benefit considerably by a strong infusion of well-trained engineers.

University College, London.

We are glad to note that University College, London, which established the first School of Engineering in the Metropolis in 1828, is fully alive to the necessity of adding to its resources in order to keep abreast of the times and providing the most modern instruction and equipment for the young men who will eventually become leaders in their profession. In view of the necessities of the case there ought to be no difficulty in providing the sum of 100,000*l.* which is required to carry out the extension and re-equipment which the times demand. It is only right that our young engineers, especially those who have borne the brunt of the war, should have every opportunity of acquiring the best possible education. The needs of this country make such training a vital necessity since engineering ability is an essential factor in practically all the main industries in which we compete with other nations for world trade. This country must, above all things, produce the educated brain power required for guiding and directing our great engineering trade. We cannot expect to do this with third-rate resources and equipment, and it is clear that America recognises this, since private benefactors there are giving millions of money with the patriotic motive of providing their young men with the best educational facilities that can be secured. We are, as we have said, therefore glad to note that this appeal for funds to carry on so vital a work has commenced very auspiciously with a gift of 10,000*l.* from Lord Cowdray, with a promise of a like sum when 70,000*l.* has been reached, while in addition to other substantial gifts members of the family of the late Mr. Charles Hawksley have contributed 3,000*l.* towards a development of the Hydraulic Laboratory to be associated with his name. Substantially 30,000*l.* has already been given, and it is hoped that the remaining 70,000*l.* will be quickly subscribed. In an early issue we propose to describe the proposed extensions and to deal with the work of this School of Engineering which has in the past played so great a part not only in engineering education, but also in advancing the boundaries of engineering science.

The James Watt Lecture.

The James Watt anniversary lecture at the Watt Institution, under the auspices of the Greenock Philosophical Society, was delivered on Friday evening last by Professor C. G. Barkla, F.R.S., who took as the text of his discourse the remarkable discoveries made during the past twenty-five years, in regard to the constitution of the chemical atom. Sir J. J. Thomson—"the greatest scientific genius of modern times"—was, he observed, the first to prove that electricity could exist apart from matter, by demonstrating that the cathode particles in a vacuum tube had masses only $\frac{1}{1,700}$ of the mass of the lightest known atom. Since then, the lecturer observed, these electrons had been obtained from matter in many different ways, viz., by the action of heat, by bombardment with α or β rays, by exposure to ultraviolet light, or to X-rays; whilst in the case of the radioactive elements, the electrons were spontaneously emitted. It thus appeared, the lecturer said, that the electron was a constituent of all matter. It was, moreover, the same with all radiation, whether it was the Marconi wireless waves generated by the surging of electrons up and down the antennæ at a signal station, or the X and gamma rays generated by the extremely rapid oscillations of electrons inside the atoms themselves. It was interesting, Professor Barkla continued, to note that the best reflectors of light were the best conductors of electricity, because both qualities were due to the presence in the reflector or conductor of large numbers of "free" electrons. Whilst negative electricity had, as stated, been found in the free state as a cathode particle, or electron, nothing similar had been observed in the case of positive electricity, which was never found associated with any mass less than that of a hydrogen atom. It had accordingly been suggested that the atoms consisted of a uniform sphere of positive electricity, having embedded in it large numbers of electrons. On this hypothesis the whole mass of the atom would reside in the electrons. It had been proved by the speaker, however, on measuring the scattering of X-rays by material bodies, that the number of electrons present in an atom was, in general, small, being one in the case of hydrogen, and six in that of carbon, and so on, and Rutherford, from other experiments, had concluded that the actual number of electrons present in an atom was about half of the atomic weight, and that the positive charge instead of being diffuse was most highly concentrated into the nucleus of the atom. The atom is accordingly now regarded as consisting of a few specks of electricity separated by spaces vast in comparison with their own dimensions. Hence what was called a solid body was, the lecturer said, nearly all empty space. This theory received support from radioactive phenomena. When a radioactive body broke up, the α particles were hurled out at a very high velocity, and it was found that they could pass through tens of thousands of other atoms without being much deviated from their course. Only in rare cases was there a violent collision, and this indicated what a very small space the colliding particles really occupied. In recent experiments, Rutherford had found that when an α particle did collide with the nucleus of a nitrogen atom it knocked out of this nucleus a hydrogen atom. Hence there was evidence that we had here the means of transmuting apparently stable elements.

Petroleum and the Production of Helium.

In our issue of May 2, 1919, page 574, we gave a summary of the work of the United States Bureau of Mines on the Extraction of Helium from Natural Gas, following in the main the address on the subject which Dr. F. G. Cottrell delivered at New York when receiving the Perkin medal. The recent pamphlet on "Petroleum Investigations and the Production of Helium," by Dr. Van. H. Manning (Bulletin 178c, being part of the advance sheets of Bulletin 178 of the Bureau), does not carry the matter further as regards technical particulars, but gives an account of the somewhat chequered history of the technical researches and briefly notices the actual condition of the helium plants. The occurrence of helium in natural gas was first communicated to the American Chemical Society in 1907 by H. P. Cady and D. F. Macfarland. The Bureau of Mines became, in 1916, interested in a new air separation process of F. E. Norton, of the Massachusetts Institute of Technology, and E. A. W. Jefferies, the primary object of this process being the production of oxygen for air blasts. The suggestion of filling airships with helium came from England, as we stated on the former occasion. The Bureau first placed the helium researches in charge of G. A. Burrell; but the *personnel* underwent frequent changes until Dr. Manning, the director of the Bureau, took charge himself. Contracts were made with the Linde Air Products Company and the Claude Air Reduction Company for the first two works, which were known as Argon [not Helium] Plants No. 1 and 2; the actual construction was done by the Army Corps and the Bureau. These plants were completed in March and May, 1918. Plant No. 3 (Norton) was not started before April, 1918, because both the Navy and Army had originally opposed the Norton scheme. Another helium plant also projected, by the B. S. Lacy process, was dropped. Plant 1—and later also Plant 2—was able to produce helium of 92·5 per cent. purity, which was stored in steel cylinders containing 200 cub. ft. of gas under normal conditions at a pressure of 2,000 lb. per square inch; 750 of these cylinders were ready for shipment at New Orleans when the armistice was signed, and were then returned to the works at Fort Worth, Texas. After long discussions between the various departments it was decided, in January, 1919, to shut down both the Linde and the Claude plants, but to allow the latter company to continue operations for three months on its own account. Plant 3 (Norton) was permitted to go on with a new grant in April, 1919, as the process seemed to promise the yield of a helium of the highest purity; the actual purity reached at that time was, however, only 21 per cent. according to the Bulletin, and that figure does not appear to be a misprint. The Bulletin also deals with Petroleum Investigations as we mentioned, and particularly with specifications for motor fuel, including aircraft fuel. It also treats of gasoline recovery and refinery, oil and gas production and with laboratory tests.

Almanacs and Calendars.—The following calendars have come to hand. Messrs. John O. Thornycroft and Co., Limited, Southampton, Basingstoke and London, showing large and small Thornycroft vessels in a North Sea engagement. A desk calendar from the British Rawhide Belting Company, Limited, Hythe-road, Willesden, N.W. 10; a monthly calendar from Messrs. Jones and Shipman, Limited, Leicester, illustrating various machine tools and tools of their manufacture; a monthly calendar from Messrs. Alfred Herbert, Limited, machine tool manufacturers, Coventry; a desk calendar from the British Steel Bar Company, Limited, 17, Victoria-street, Westminster, S.W. 1; a daily tear-off calendar from Messrs. E. G. Wrigley and Co., Limited, Foundry-lane Works, Soho, Birmingham; a monthly calendar from the Wellman-Seaver-Morgan Company, Cleveland, Ohio; and a very clear monthly calendar from Messrs. Langhall and Wade, printers, designers, &c., 10, South-street, Finsbury, London, E.C. 2.

LITERATURE.

A System of Physical Chemistry. By WILLIAM MCC. LEWIS, M.A., D.Sc., Brunner Professor of Physical Chemistry in the University of Liverpool. Second edition. Three volumes: Vol. I. *Kinetic Theory*; Vol. 2. *Thermodynamics* [prices, 15*s.* each, net]; Vol. III. *Quantum Theory*. London: Longmans, Green and Co. [Price, Vols. I and II, 16*s.* each; Vol. III, 7*s.* 6*d.* net].

THE second edition of Professor Lewis' "System of Physical Chemistry" is not announced as a revised and enlarged edition, though it might be described as such with more right than many a modern edition which especially claims to have been thoroughly brought up to date. There are plenty of references to the years 1917 and 1918; several new sections have been added to the work, and the third part of the second volume (of the first edition) has grown into a third volume. The first, 1916, edition of the work was reviewed in our issue of December 8, 1916. A slightly larger size, and the adoption of another type further make the three new volumes of a larger compass than the former two volumes.

The additions in volume I are chapters on the X-ray examination of crystal structure, the properties of the colloidal state, the dissociation of ammonium chloride, the dual theory of catalysis (originated by Senter and by Acree), the displacement effect (the effect on the velocity of reaction of gradually displacing one reactant by another in a bimolecular solution), and Langmuir's theory of evaporation, condensation, adsorption and heterogeneous reaction velocity and catalysis. Langmuir described this theory as an extension of Bragg's work upon crystal structure to chemical processes, and his forces are all chemical. One would have expected that stress would in general be laid on the residual affinities possessed by the atoms in the surface layer, which is assumed to differ from the interior of a substance; but this consideration is not developed.

The chapter on crystal structure and X-rays is disappointing, in one respect. It confines itself to the work of W. H. Bragg and W. L. Bragg; that would be sufficient, if the usual literature references were given, in which Professor Lewis generally excels; but Laue's name is just alluded to, there is no reference to the varied work of his collaborators, and nothing is said about the important researches of Broglie, Debye, Scherrer, and others. The omission is probably to be ascribed to the general limitations imposed upon the author by expediency and the consideration that other volumes of the Text Books of Physical Chemistry—to which series this work belongs—are devoted to special domains of Physical Chemistry. Valency, isomerism, isotopes, as well as chemical engineering problems such as water-gas production, remain excluded, and the chapter on affinity (in volume II) treats the problem from the thermodynamic standpoint. The additions to this volume concern the mechanism of osmotic pressure (too much limited to F. Tinker's standpoint, it may be objected), and the modern theory of dilute solutions of electrolytes (after G. N. Lewis Bates and other American workers).

In the third volume, dealing with Considerations based upon the Quantum Theory, Professor Lewis does not adhere to his original attitude towards experimental material. The theoretical concepts of which he made use in his first two volumes, he points out, have become classical; and his treatment resolved itself into a brief account of principles followed by a systematic application of these principles to phenomena characteristic of systems which had attained equilibrium or were tending towards equilibrium. The underlying ideas of the quantum theory have not yet been fully accepted, at least not in their present form; the physical significance of a quantum of energy or a quantum of atom is still vague. Professor Lewis quotes Professor Bragg: "Planck's hypothesis is not so much an attempt to explain as a focussing of all the difficulties into one; so that, if this master difficulty is overcome, a number of others melt away." Professor Lewis exposes the general considerations which forced the quantum idea on Planck and Einstein in connection with a review of researches which were especially carried out or resumed for the purpose of testing the theory. His first two volumes having been headed Kinetic Theory and Thermodynamics; the third might be headed Statistical Mechanics. We have to deal, he explains, with essentially molecular processes in terms of molecules; we cannot trace the individual molecule in a gas, and have hence to deal with averages by the theory of probability of Maxwell and Boltzmann and the method of statistical mechanics. That the second law of thermodynamics has a statistical basis was shown by Boltzmann. Heat is represented by the kinetic energy of the molecules. If we start with a gaseous system, the molecules of which are in an ordered condition, the molecular collisions tend to reduce that condition to disorder and to maximum "mixed-upness." Work can be converted into heat, but heat cannot completely be converted into work, because ordered motion tends to become disordered. The motions may be of three kinds, translational, rotational and vibrational—this last motion requiring a restoring force. Each of these types of motion has its own degree or degrees of freedom, and according to Maxwell and Boltzmann the average kinetic energy is equally distributed among the various degrees of freedom. That law of the "equipartition of energy" was reluctantly accepted by many scientists; as late as 1900 Rayleigh pleaded for some means of escape from the destructive simplicity of its general conclusion, though that might involve repudiation of some of Maxwell's fundamental postulates. Planck broke with the equipartition principle in 1901.

Equipartition implies an interchange of energy between ether and matter in a continuous manner and in any quantity. Max Planck suggested that the exchange could take place only in steps and in multiples of a minimum quantum ϵ. The further suggestion, that radiant energy itself has a structure, is due to A. Einstein, and this hypothesis, Professor Lewis remarks, was given a physical basis by J. J. Thomson's radiation unit of a tube of force. Planck mainly wished to explain, in the first instance, the mode of emission and absorption of radiant energy. If the ether were structureless, endowed with an infinite number of degrees of freedom and capable of propagating all waves of any lengths, the ether would take up all the energy, leaving none to matter. If the ether had a structure and a finite number of degrees of freedom, the energy distribution in the spectrum should be inversely proportional to the wave length, and the energy should hence be concentrated in the ultraviolet (Rayleigh and, later, Jeans). But the studies (before 1900) of black body radiation (Lummer and Pringsheim) had once more established that the main portion of the energy is in the infra red. To every degree of freedom we must, however, assign at least one quantum of energy, and the emission in quanta does not, at first sight, appear to account for the energy distribution in the spectrum either. But Planck's quantum is not supposed to have one fixed value; it is defined as $\epsilon = h\nu$, where ν is the frequency of the vibration and h what has become known as Planck's universal constant, $h = 6{\cdot}547 \times 10^{-27}$ erg per second (Millikan's value of 1917). The spectrum is produced by a system of vibrators (or resonators) consisting of molecules, atoms and electrons. In the long-wave range the ν is small, the ϵ, the individual energy of each vibration, will also be small; but the probability is that many vibrators will possess that amount of energy, and their cumulative effect will be large. In the short-wave region the ν and the ϵ will be large; but just for that reason few vibrators will possess the necessary energy for this emission, and hence the energy falls off in the visible and ultraviolet spectrum. Numerically the ϵ range from $2{\cdot}1 \times 10^{-14}$ erg (for $\lambda = 90\ \mu$ in the extreme infra red) to $2{\cdot}47 \times 10^{-12}$ (for $\lambda = 0{\cdot}8\ \mu$ in the visible red) and to $1{\cdot}9 \times 10^{-11}$ in the Schumann-ray region ($\lambda = 0{\cdot}1\ \mu$). Some difficulties, notably in connection with the Maxwell-Hertz electrodynamic equations, caused Planck in 1911 to modify his theory in so far as to admit continuous absorption of energy, whilst the emission was to be restricted to steps as before. There remains the chief difficulty that interference can hardly be explained on quantum lines. Einstein's law of photochemical equivalence—that each molecule of a photo-sensitive substance requires one quantum of the respective energy for its decomposition—is also contradicted by some experiments of Baly, Bodenstein and Warburg; but the interpretation of all these experiments is very difficult.

Having outlined the quantum theory Professor Lewis discusses recent researches supporting it. The work of Nernst, Koref and Lindemann on specific heat, and on atomic and molecular heats, both at high and at very low temperatures proved that the atomic heat of solids increases (decreases) with rising (falling) temperature; if new degrees of freedom were to come into action, that increase should be in steps; but it is continuous, and the whole phenomena are unintelligible on the equipartition principle, whilst the formulæ deduced by Debye on the quantum principle explain them satisfactorily. Further support is afforded by the studies of the characteristic frequencies and the thermal properties of gases (Bjerrum, Eucken, Eva von Bahr); of thermal reactions; of Nernst's heat theorem, and of photoelectric effects (J. J. Thomson, Tate and Foote) and photochemical equivalence (already alluded to). These and other researches are reviewed at some length. Three appendices (taking up a quarter of the volume), compiled by Professor Lewis' colleague at Liverpool, Mr. James Rice, M.A., further deal with Maxwell's Distribution Law and the Principle of Equipartition of Energy, the Foundations of the Quantum Theory and Krüger's Theory of Gyroscopic Molecules (1916). The embodiment of these sections, which partly follow different lines of argument, testifies to Professor Lewis' breadth of view. F. Krüger, as Professor Lewis generally explains in his section on degrees of freedom, substitutes precessional rotation for true molecular rotation. For the simple nucleus an axis of rotation is insignificant. When the atom consists of nucleus and electrons, and the molecule of atoms, themselves gyroscopes, collisions will give rise to precessional rotations—a very important suggestion for the interpretation of the phenomena of monatomic gases and of spectra in general.

The quantum hypothesis is pervading all domains of physical and chemical theories. Our readers may remember that, like Bohr, Sir J. J. Thomson, in his Royal Institution lectures of last spring, applied it to his views on spectra. Planck himself and Reiche and Epstein have recently made the top spin on the quantum principle. If the principle really enables us to focus all the difficulties into one, it will have served its object; no theory can do more. It has already helped us to understand and to correlate many obscure problems, and Professor Lewis is sure to enlarge the circle of friends of his System of Physical Chemistry by having added to it a third volume on statistical mechanics and the quantum relation.

BOOKS RECEIVED.

Factory Management Wastes and How to Prevent Them. By JAMES F. WHITEFORD. London: Nisbet and Co., Limited. [Price 12*s.* 6*d.* net.]

Scientific Factory Management. By ARTHUR DU PRES DENNING, M.Sc. London: Nisbet and Co., Limited. [Price 12*s.* 6*d.* net.]

La Bataille Navale au Skarrack. Par Capitaine de Vaisseau A. POIDLOUE. Paris: "Editions et Librairie," 40, Rue de Seine. [Price 3 francs.]

Mineral Resources of Georgia and Caucasia. By D. GHAMBASHIDZE, F.R.G.S. London: G. Allen and Unwin, Limited; New York: The Macmillan Company. [Price 8*s.* 6*d.* net.]

Manuel de Culturi Mecanique. Par C. JULIEN. Paris: Librairie Hachette. [Price 4 francs.]

Mechanical Engineering, 1920. Foster's Pocket Reference Books. No. 1. Manchester: Frank Foster, 98, College-road, Whalley Range. [Price 2*s.* net.]

Iron and Steel Works, 1920–21. Foster's Pocket Reference Books. No. 2. Manchester: Frank Foster, 98, College-road, Whalley Range. [Price 2*s.* net.]

Manual of Motor Mechanics and High Efficiency Tuning. (The functional working of the petrol engine.) By L. MANTELL. Fourth edition. London: Temple Press, Limited, 7 to 15, Rosebery Avenue, E.C. 1. [Price 3*s.* 6*d.* net.]

Examples in Heat and Heat Engines. By T. PEEL, M.A. Cambridge: The University Press. [Price 5*s.* net.]

THE LATE MAJOR EVAN ROWLAND JONES.—We are sorry to find it announced in our contemporary *The Shipping World*, that Major Evan Rowland Jones died on Friday morning last, the 16th inst., in his eightieth year. From its establishment, in 1883, Major Jones was the editor of that journal, and since 1893 he was the sole managing director of the company.

INSPECTION-AMBULANCE MOTOR TROLLEY ON THE MESOPOTAMIAN RAILWAYS.

(*For Description, see opposite Page.*)

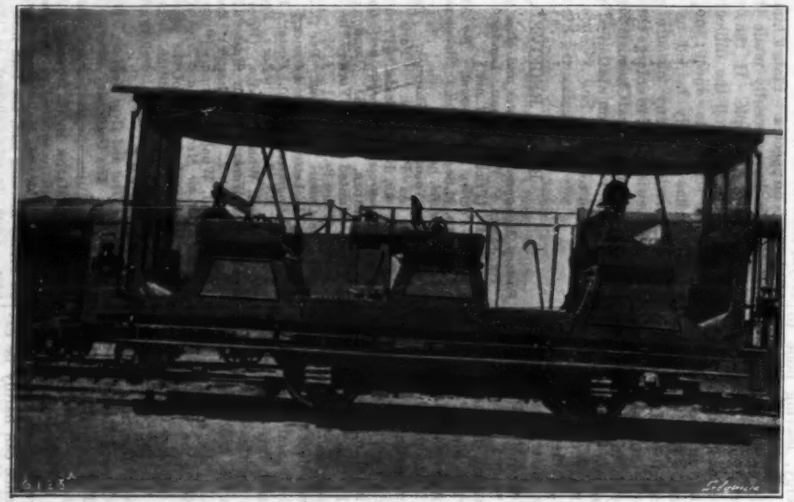


FIG. 1. THE TROLLEY AS AN INSPECTION TROLLEY.

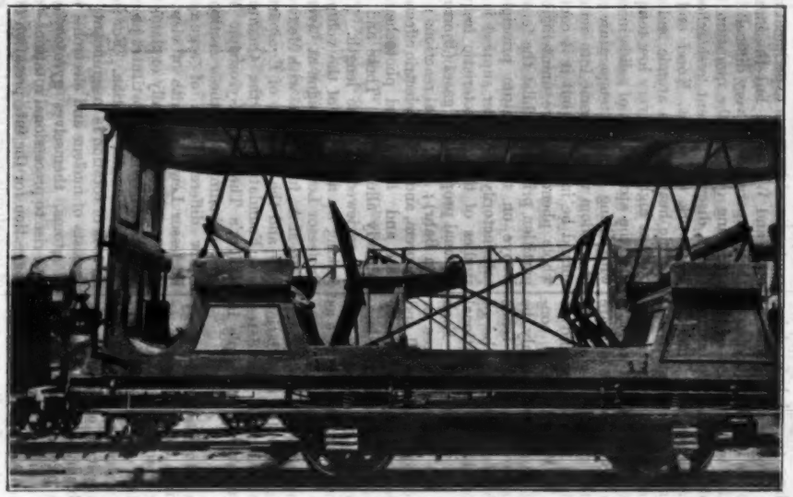


FIG. 2. COLLAPSIBLE FRAMES BEING RAISED.

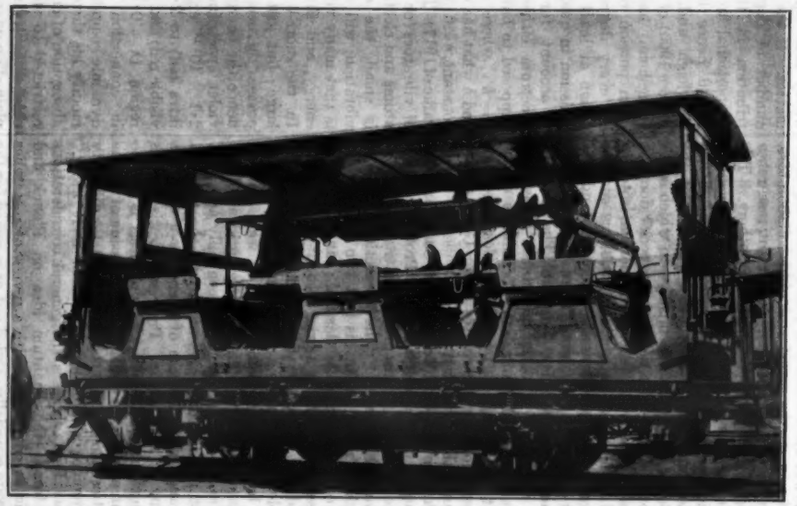


FIG. 3. STRETCHER CASES BEING LOADED UP.

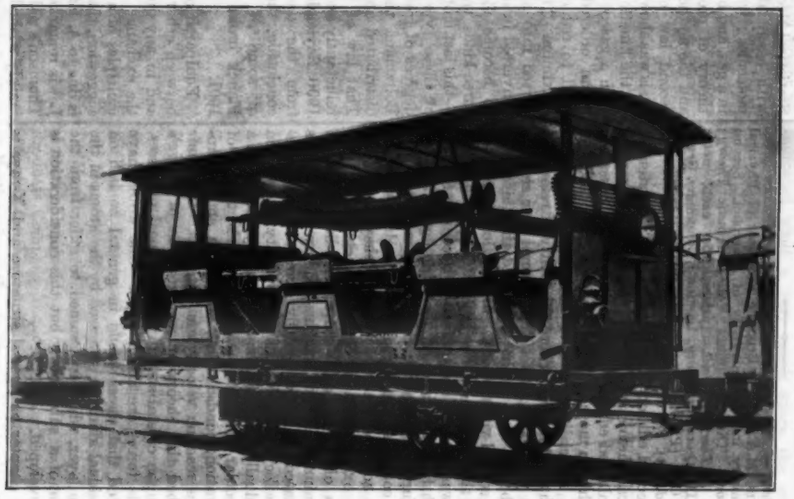
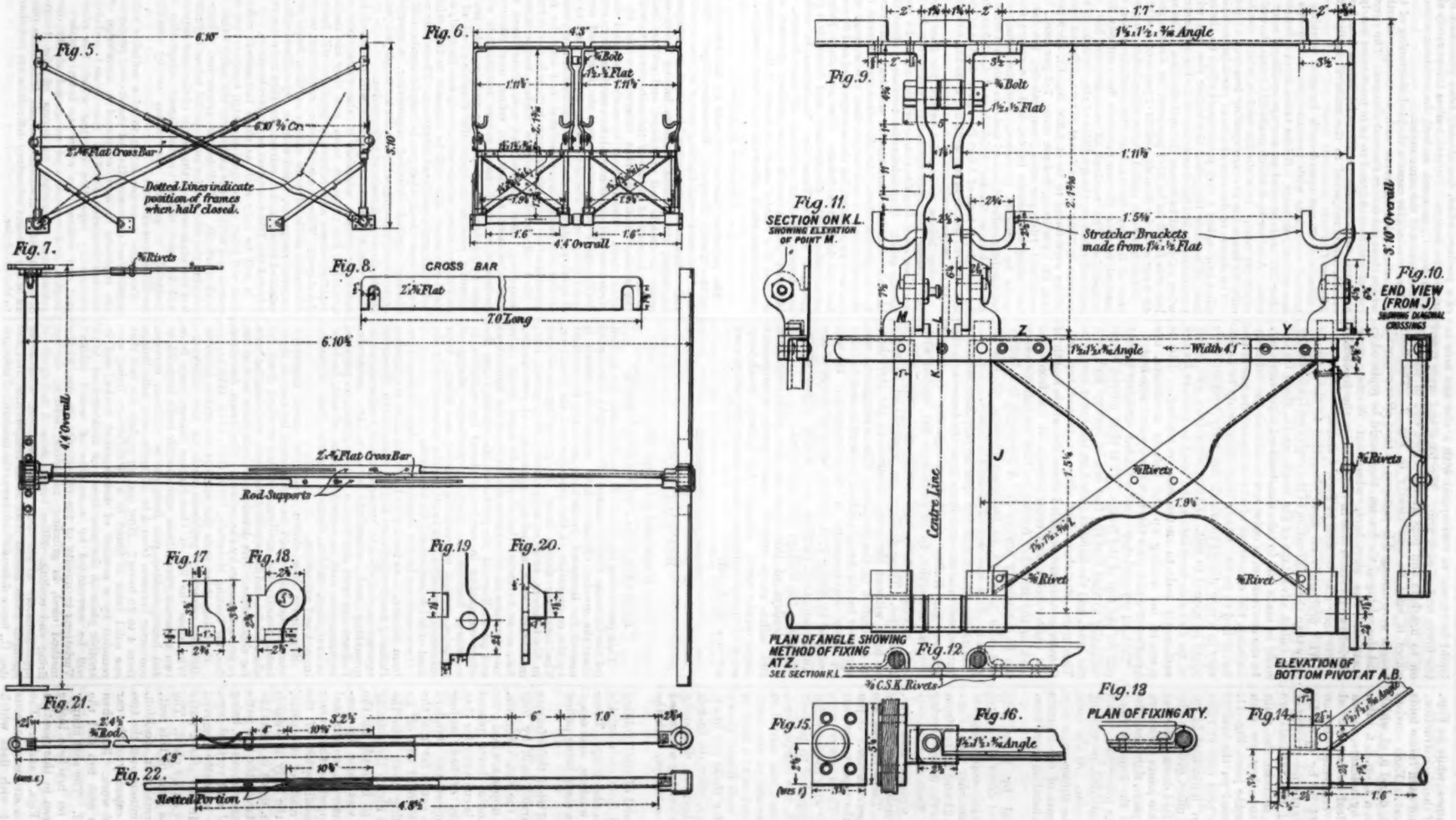


FIG. 4. THE AMBULANCE TROLLEY WITH FOUR STRETCHER CASES ON BOARD.

INSPECTION-AMBULANCE MOTOR TROLLEY ON THE MESOPOTAMIAN RAILWAYS.



INSPECTION-AMBULANCE MOTOR TROLLEY ON THE MESOPOTAMIAN RAILWAYS.

During the recent campaign in Mesopotamia a light railway (2-ft. 6-in. gauge) was used when practicable, ahead of the metre-gauge permanent system, which followed up country as the advance proceeded. On this 2-ft. 6-in. system a number of motor ambulance trolleys were employed, which were no longer required when the use of this narrow-gauge line was abandoned after the metre-gauge system had extended beyond Baqubah on the Dialah River. It was then decided to convert many of these trolleys from narrow-gauge ambulance cars to metre-gauge inspection trolleys, in which form they were used by the railway technical staff, and also to a very great extent by the General Staff for military inspection and other duties. Some of these trolleys were also converted to standard gauge for the system on the right bank of the Tigris.

The conversion of the Drewry cars selected, to metre gauge, did not involve much structural alteration. On the Kut-Hinaidi and Baqubah division, the frames were spread wider apart by introducing distance castings at both ends of the stretchers or cross members, and new axles were provided. Small modifications in the staying were introduced as well. In converting to standard gauge the principal change was the conversion of the axles from outside to inside journals, which practically accounted for the difference in gauge, and the addition of angle-iron extension frames along the sides to take a wider body. In both instances the body fitted had three transverse seats. The seats were not upholstered, but were made up of wooden slats, and comfortably curved. The general type of body adopted may be seen in Fig. 1 on the opposite page. The whole of the central box-seat was made removable so that if necessary a large amount of kit or gear could be placed on the floor, which thus provided on the metre-gauge cars a flat space measuring about 7 ft. 7 in. by 4 ft. 6½ in.

Subsequently the medical authorities asked that ambulance trolleys should be provided on the metre-gauge system, and in order to make these more generally useful than they would have been had regular ambulance bodies been fitted, it was decided to design fittings which would enable some of the inspection cars to be used for either ambulance or general work, as desired. The medical authorities required accommodation for four stretcher cases and the provision of ice and water. On the other hand, the arrangements were not to interfere with the use of the trolley for inspection work or with the carriage of kit on deck. To meet these requirements collapsible frames to take four stretchers were designed, which, when out of use, shut up into shallow boxes under the floor. Figs. 2 to 4, page 126,

show a trolley fitted with these frames, while in Figs. 5 to 22, page 127, we give details of their construction.

There are two frames to a set, and each frame folds down between the end and centre seat. Each consists of two leaves, as shown in Figs. 2, 5, 6 and 9, of which the lower is carried by and turns on a 1½-in. G.I. tube, 1¾-in. O.D., fixed across the body by brackets, shown in Figs. 9, 14, 15 and 16. This leaf is constructed of four ¾-in. G.I. pipe verticals connected by an horizontal member at the top of 1½ in. by 1½ in. by ⅛ in. angle, and stiffened by two sets of cross-bracing of similar section. At the lower end the verticals are fitted with large lugs, bored out to take the main supporting, 1½-in. tube; at the top they are each fitted with the lower half of a knuckle joint, Fig. 11. The upper part of this pair is formed on the end of verticals, 1½ in. by ½ in., which are bent over at right angles at the top and riveted to an horizontal 1½ in. by 1½ in. by ⅛ in. angle. By the offset given to the centre knuckle pins, the two leaves fold down quite flat on themselves. Details of the knuckle joints are shown in Figs. 17 to 20. They are made in pairs, right and left-handed. A lug on the top half of the knuckle joint comes in contact with a stop on the lower part, when the joint is opened and the frame unfolded, preventing the upper leaf being pushed over too far. At the same time a small wedge extension of the upper arms slips into a tapered grip on the lower part of the knuckle joint, giving the upper frame additional support sideways.

The frames are held extended by three sets of stays. Two of these are arranged down the centre of the car. They consist of a pair of telescopic diagonal stays and a long cross-bar or stretcher rod, Figs. 5 and 7. The telescopic stays, Figs. 21 and 22, run from near the top of each upper frame, to the main carrying 1½-in. tube of the opposite frame. Each stay consists of a ¾-in. rod working in a ¾-in. wrought-iron pipe. Slots in both are cut to take a small cotter, rightly placed for the correct extension. These cotters are fastened to the stays by chains to prevent loss. A pin on the rod also works in a slot in the pipe, to prevent the stay running out too far. These stays were arranged so that they fouled slightly with the intention that when up they should press together to prevent rattling. The long cross-bar, Fig. 8, was independent, and, when the frames were not in use, was carried in clips provided for it on the underside of the roof. When in use it was slipped at each end on to a head on one of the central knuckle pins of each frame, shown in Fig. 9. In order to get room for these pin heads and the telescopic stays in the centre, when the frames were folded, this stay extended between diagonally opposite centre knuckles. In use, this stay was forced home between the telescopic diagonal stays, with the result that all dither was avoided.

The remaining set of stays consisted of small folding diagonals (see Figs. 5, 6, 7 and 9) from each outside vertical of the lower leaf down to the body. These were fitted at the joint with spring washers, and snap-locked. They had lugs to prevent them being pulled up beyond the straight.

Four stretchers are accommodated when these frames are raised. The two lower are carried each by four brackets, Figs. 6 and 9, just above the knuckle joints, taking the stretcher handles. The upper are laid over the top horizontal angle, the handles being placed where the vertical of the angle iron is cut away for that purpose. There was no possibility of bad loading longitudinally, as the frames support the standard army stretcher outside the legs, but not so far from the latter that the end of the handle could slip off its support. With these frames folding down into the shallow boxes under the floor, but above the running gear of the trolley, provision had to be made for the telescoped diagonal stays. This was done by connecting the two main boxes by a narrow, longitudinal trunk into which these stays dropped as the frames collapsed. This necessitated a modification of the centre seat. The box of this was made of two parts, each extending from the outside of the body in towards the centre as far as the trunk, a 3½ in. space in which the diagonal stays moved being left between the two parts in the centre. These two box seats were removable, being kept in place merely by horizontal and vertical lugs, so that, as before, they could be instantly removed if the floor space were required. In one side a water tank was provided, and in the other an ice chest. The bottom stretcher, when loaded, was clear of this seat, which therefore could remain normally in position. The batten seat top was made continuous over the two boxes, so that the original seating capacity of the car was not affected as regards general work. But when the frames were to be used, this seat top and the throw-over back had to be removed. The seat simply lifted off and was hung by lugs on brackets inside one end of the car. It may be seen in this position at the right hand end of the car in Figs. 3 and 4. The throw-over back was arranged with an instantaneous release, its pivots being provided with flats which could be turned to correspond with a slot and hole in the lower end of each arm. The back and arms fitted on to brackets and pins at the other end of the car, where it may be seen clearly in Fig. 2. The floor boards were arranged in sections so that after removal, and the raising of the frames, they could be replaced in position. The stretchers, when not in use, were carried two on either side in boxes below the footboard where they may be seen in Figs. 1 and 2.

With practically no more alteration to the original body than the modification of the centre seat, and taking the fullest advantage of the inside width, these frames could be made just to take the standard army stretcher. In the conversion, in order not to disturb the old body framing, the clearances of the collapsed frames in the boxes had to be cut rather finer than would be necessary in a new design in which the body longitudinals could be spaced to suit. Every advantage was taken of the full clearance inside the body to procure frames sufficiently wide to ensure ease in loading. This is essential for loading up the bottom stretchers, the handles of which pass through the upper frame leaf.

To load up stretcher cases a loaded stretcher is first put on the top of the frame. It is then moved longitudinally so that first the feet can be lowered and then the head, and the handles rested on the lower brackets. The upper stretchers just slide on to the top bar. Canvas screens are provided down the whole length of the trolley body, and cross screens at the front and back of the stretcher frames, so that ambulance cases can be completely protected. A telescopic iron ladder was also provided to facilitate loading on uneven ground. This was carried under the frame.

With the driver, and one man to help him raise the frames, and take the stretchers from the bearers on the ground, the trolley could be completely converted from an inspection to an ambulance car, loaded with four stretcher cases, and could get away within 2½ minutes. These trolleys ran upwards of 35 miles an hour without the least vibration to the stretchers or discomfort to the patients. The arrangement was approved by the Army medical authorities and fulfilled all their requirements in these respects. It was designed by Major P. J. Cowan, when in charge of the Kut locomotive, carriage and wagon repair shops, where also the trolleys were converted.

As trolleys of this type can run with ease over 200 miles at a stretch, some such arrangement might easily prove valuable for railway breakdown work in many countries where motor inspection cars are now employed.

REFRACTORIES.

(*Concluded from page 99.*)

"*Refractories in the Iron and Steel Industry.*"

This paper was by Mr. C. E. Nesbitt and Mr. L. Bell (of the Carnegie Steel Company, Pittsburgh), who stated that the greater efficiency from refractories which is needed for increased production can only be attained by the co-operation of the consumer and the producer. The consumer should know the prevailing conditions in his furnaces, such as temperature, slag, gases, dust, mechanical wear, abrasion, expansion and contraction, &c., so as to know what the bricks must stand. The manufacturer of refractories should know the limitations and possibilities of his product. He should know the effect on quality in service produced by variation in moisture, fineness of grind, proportionate sizing of particles, method of moulding, drying and firing. Such information enables him to advise the consumer as to the kind of brick best suited for his needs.

Temperatures in the interior of a blast furnace vary from 200 deg. C. at the top to 1,800 deg. C. at the tuyeres. Refining temperatures are high in open-hearth, Bessemer converters, and electric furnaces, whilst temperatures in quenching and annealing furnaces are moderate. Refractories must also meet a wide variation on physical requirements, such as corrosive action of acid, basic or neutral slags, sudden thermal changes, load, abrasion, impact and expansion.

Experience has shown that the most important working qualities could be determined by two or three tests, namely, the spalling and hot-crushing tests for silica bricks, and the spalling, hot load, and slagging tests for clay bricks. The detailed methods have been given in previous papers by the authors. (See Trans. American Soc. for Testing Materials, 1916, 1917, 1918, 1919.)

By using these tests the authors are trying to solve difficult refractory problems such as the following: Why does the life of blast-furnace linings vary from two to seven years, basic open-hearth roofs from 25 to 400 heats, soaking pits from six to eighteen months, converter bottoms from 4 to 16 heats, and ladle linings from 4 to 25 heats? How can we explain the fact that one solid brick is found in a blast-furnace lining surrounded by a number of disintegrated bricks, and in another place on the same level one disintegrated brick will be surrounded by a number of sound bricks? Variations in quality of the refractories are due to the method used, in grinding, moulding, setting, drying, firing and cooling. Silica bricks show a falling-off of approximately 50 per cent. to 60 per cent. in crushing strength when heated from room temperature to 1,350 deg. C., hence defects which lower the mechanical strength of a product which has already been weakened by heat are serious factors. Defective silica bricks rarely show at 1,350 deg. C. as much as half the crushing strength of sound bricks of the same make.

Fire cracks also cause a decided shortening of the life of a silica brick structure such as an open-hearth roof, where there are severe thermal changes. The percentage loss of weight was found to be in most cases nearly twice as much as in similar commercial bricks free from fire cracks, when subjected to the authors' spalling test at 540 deg. C.

Roofs of 90-ton open-hearth furnaces working under normal conditions with producer gas should last for a average of 200 heats. Bricks taken from a furnace roof after 261 heats showed an average spalling loss of 20 per cent. Another roof which made 221 heats showed a loss of 23 per cent. In a similar roof in which the life was only 80 heats the average spalling loss was 47 per cent.

The degree of fineness or size of particles, especially in silica bricks, has a very pronounced effect on the spalling loss. The finer the grind the higher the loss, which in turn means a decided shortening of the life of the structure when subjected to severe thermal changes. The spalling loss was found to be 30·4 per cent. for 4-mesh material, 47·6 per cent. for 8-mesh, and 63·2 per cent. for 16-mesh.

What has been stated about silica bricks is generally true of fireclay bricks, but the deviations are not so marked, because the raw materials have entirely different properties. The method of manufacture has a pronounced effect on the qualities of clay bricks. Thus the average spalling values found for six different brands of bricks were found to be at 1,350 deg. C., 26·9 per cent. loss, 11·7 per cent., 9·4 per cent., 7·3 per cent., 3·4 per cent. and 16·7 per cent., respectively, the last three lots being hand-made bricks, and the others machine-made by different processes. For the same series of bricks the results of a load test—in which a steel ball is pressed into a fireclay brick heated to 1,350 deg. C., by applying a load of 1,600 lb.—gave depths of penetration of 0·27 in., 0·46 in., 0·29 in., 0·55 in., 0·72 in. and 0·44 in., respectively.

In clay bricks, as in silica bricks, the finer the grind the greater the spalling loss; results obtained were 8·47 per cent. loss for coarse grind and 49·95 per cent. for fine grind. Clay bricks also decrease in strength when heated. Extreme variation in the degree of firing also has a marked effect. In the same consignment of clay chequer bricks it was found that the average spalling loss was 14 per cent. for the average fired and 60 per cent. for the hard-fired bricks. The consumer judges his refractories by the life obtained, and demands a product giving a more uniform life. Variations in uniformity are largely due to methods of manufacture. It is believed that a much more uniform product can be secured if a careful study is made of the variations in manufacture which affect the important qualities.

"*Superior Refractories.*"

The paper on this subject was by Mr. Ross C. Purdy (of the Norton Company, Worcester, Mass). He stated that the most vital limiting factor in the development and adaptation of electric furnaces is adequate refractories, the present furnaces having many compromises in design and operation, and serious limitation in use because of failure of the refractories to withstand the severe conditions that otherwise would be placed upon them. The increase in mechanical and dielectric strains on high-tension insulators resulting from extensive development of electric power, the increased strain on spark plugs and the increase in hazards due to failure of spark plugs in aircraft, are but two of many examples of the increasing urgencies that can only be met by materials that necessitate more intense heat treatment.

New alloys that require higher temperatures for tempering, new glasses that necessitate more intense heat treatment to melt and refine, new labour-saving devices that entail more severe temperature changes, new by-products that must be reclaimed to make the essential process commercially feasible; all of these, and many more, create an actual, not fanciful, demand for a refractory that will be superior to that which has been hitherto considered adequate. These new requirements and these changes in requirements call for a distinct applied chemical engineering, a speciality in ceramic engineering, which must be employed jointly by the producer and users of refractories.

No doubt a superior product will be found in most cases by proper selection of the refractories already available, but there are cases, and they are multiplying rapidly, where new refractory products will have to be developed. There are known requirements for refractories made of pure silicon carbide, fused alumina, sintered magnesia, fused spinels, crystallised sillimanite, calcined zirconia, &c., refractories that are not now much beyond the laboratory stage in development.

It will be only such as these last-named refractories that will meet the excessively high temperature requirements and have at the same time the many other desired heat strength, and dielectric properties. There is no denying the demand for such special refractory materials, but the plain truth is that most of the new requirements will be met either by intelligent adaptation of the materials in general use to-day or by readily-made modifications of them.

To make a proper selection of a suitable refractory requires an understanding of the several properties that are requisite in each case and a knowledge of their relative importance. This may sound pedantic and unnecessary repetition of that which has often been said and written, but when one hears chemists, metallurgists and engineers of recognised ability discussing refractories altogether in terms of the temperature of fusion and of chemical analysis, it is made plain that all of our present refractory difficulties are not chargeable to the producer.

A well-made clay refractory article will have had the fusion of the minerals carried only to that point at which maximum strength, and greatest constancy in volume are attained without distortion of the fabricated refractory article. Retaining of shape of the refractory article is the result only of stopping the progress of fusion very much short of attainment of ultimate possible strength and constancy in volume of the refractory constituents. Chemists would speak of this partial fusion as arrested reaction. It is a very important consideration how far these reactions should progress in the manufacturing of the refractories, and to what further extent they will be carried in use.

The degree of fusion is affected by such factors as compactness of the mass, homogeneity of the mixture, size of the mineral particles, and other physical factors. These physical factors result from plasticity and fineness of the clays, the degree to which the clays are pulverised, mixed and tempered; and also from the method of manufacture of the refractory article. These physical factors have a very decided and strong influence on the rate of fusion, and it is this rate of fusion that is of more importance than the possible ultimate fusibility.

It is impossible to find a melting-point in a mixture of minerals, or even in such relatively simple mineral mixtures as refractory fireclays. This is due not only to the viscosity of the melt but also to the range between the melting-points of the components or compounds present. Rather than a melting-point there is a melting range or period. A clay which, when moulded, into the standard cone shape, will squat at 1,600 deg. C., most likely will have had its fusion well progressed at 1,000 deg. C. This melting range has some relation to the rate of fusion, but can neither be stated in definite temperature terms nor closely correlated with the chemical analysis of the mixture.

Clay refractories cannot safely be judged solely on the basis of temperature of fusion, or on chemical analysis, or both.

As to the essential requirements, many refractory installations must sustain a heavy load at relatively high temperatures; others must be impregnable to gases; others must offer the least opportunity for collection on their surface of fusible solids such as coal ash; others must resist corrosion of molten glass, slag, or metal. In nearly all cases it is desirable, and in most cases essential, that the refractories maintain a constancy in permanent volume, and in most installations the refractory must be resistant to abrasion and withstand sudden temperature changes. High ultimate fusibility, structural strength, suitable density, and low permanent volume change are essential in all cases of superior refractory installation. Chemical characteristics, heat conductivity, electrical resistance, are essential considerations in a few special cases.

The frequently-used classification of refractories as acid, basic, or neutral, has a value in but very few cases, such as basic and acid processes for steel, and even with these there is evidence that too much stress has been placed on having the chemical nature of the refractory the same as that of the slag. Slag tests on bricks show that the effects of basic and acid slags have practically the same corrosive fusion effect through a very long range in composition of either the slag or the refractory. The emphasis that is now placed on basic and acid refractories will, in the vast majority of refractory installations, be found as inappropriate as the old notion that it is essential to have a course of neutral bricks between the acid silica crown and the basic magnesite linings. The refractory most suitable for a stoker furnace cannot be determined by consideration of the balance between the chemical nature of the coal ash and that of the refractory. There are, of course, exceptional cases where the chemical characteristic of the refractory is a very essential consideration, but they are very few.

Where cost will justify the expense, the superior refractory of the future will be made of fused alumina, silicon carbide, crystallised sillimanite, fused spinels, sintered magnesia, or other very refractory mineral substances that have been so fused or sintered as to have attained completed chemical change, and have come to a constancy in volume. Which will be most suitable in a given case will be much more dependent on physical than on chemical conditions, and the desired physical properties can be obtained with much more certainty with such refractories than with such materials as clay, bauxite, or calcined magnesite, in which the physical and chemical reactions and alteration have not been carried to stability.

In the case of such superior refractories there need be used either no bonding material, or (for maximum strength) only a small percentage of very fusible material such as silicate of soda, very fusible clay, or stoneware glaze. A strong, highly refractory article can be thus made of any of these materials, and have any structural characteristic desired.

"*Refractory Problems of the Gas Industry.*"

This subject was dealt with by Mr. W. H. Fulweiler and Mr. J. H. Taussig (of the United Gas Improvement Company, Philadelphia). The vertical retort system, which is now coming into general use, may be taken, they said, as a typical example of a modern coal-gas installation for the manufacture of illuminating gas. The combustion chamber in such an installation contains a number of retorts, which are heated by means of producer gas with preheated secondary air. The products of combustion pass downward through recuperators, in which the incoming secondary air is preheated. External producers are used in the most recent installations.

The coal gas passes from the tops of the retorts to the condensing, scrubbing and other purifying apparatus. The temperature in the combustion chamber is 1,450 deg. to 1,550 deg. C., and in the lower part of the retorts 1,350 deg. to 1,500 deg. C., gradually decreasing upwards to about 850 deg. C. at the top, where the gases enter the recuperators. The gradual decrease continues through the recuperators, from which the gas passes at a temperature between 480 deg. and 530 deg. C. The incoming air from the atmosphere leaves the recuperators at about 760 deg. C. The retorts, which are about 23 ft. long, with a heavy iron casting to form the upper mouthpiece, are charged with coal at intervals of 10 hours to 12 hours.

From economical considerations it has been necessary to use both silica and fireclay materials, which makes the design and construction of these modern retort benches a very complex problem. The average silica material will expand about $\frac{1}{16}$ in. per foot, and the average fireclay material under the same temperature conditions will probably expand $\frac{1}{32}$ in. Most of the expansion of the silica—especially when the setting is first heated up—takes place at 300 deg. to 350 deg. C., whilst fireclay expands gradually up to about 1,100 deg. C.

The bench structure may be regarded roughly as a rectangular column of silica material, floating on a cast-iron base, which at the existing temperature has about the same expansion as the fireclay, surrounded by a retaining wall of fireclay material and enclosed in a heavy steel framework.

The double arches of the combustion chamber are of the highest grade silica material, so as not only to resist the very high temperature, but also to support a load which may amount to 25 lb. per square inch. The retorts are of silica, and the recuperators of fireclay. The combustion chamber lining is also of silica.

The benches are usually built in stacks of about 90 ft. in length, and allowance is made for 4 in. expansion in this length. The high-grade silica material used in the combustion chamber, retorts and connecting blocks, contains over 96 per cent. silica with about 1·5 per cent. lime, acting as a bond. The fireclay material used in the recuperators contains 55 per cent. silica, the rest being alumina, with a little lime, ferric oxide, &c. Fireclay is also used at the tops and bottoms of the retorts (owing to its smaller expansion and greater resistance to spalling), because of the rapid changes of temperature resulting from the high conductivity and radiation of the brickwork. The outside walls are made of a lower grade of firebricks, and the whole bench structure is insulated with bricks made from infusorial earth. One bench of nine retorts will require about 76 tons of silica material and 108 tons of fireclay material.

The standard form of water-gas apparatus consists generally of three steel shells, lined with firebricks and insulating material, and termed respectively generator, carburettor and superheater. The generator has a grate, and connections for introducing air under pressure and steam, both below and above the grate; there are also reversing valves and connections by means of which the products of combustion may be taken from either the top or the bottom of the generator. These connections also connect with the top of the carburettor, which is lined with firebricks and with chequer bricks. The bottom of the carburettor communicates with the superheater, which is constructed like the carburettor, and has a stack valve at the top for letting off waste gases, and which is also connected with the cooling and purifying system for the water gas produced.

When working, the fuel in the generator is highly heated by the aid of an air blast directed from beneath the grate. In order to burn any combustible gases in the producer gas thus formed, air is admitted at the top of the carburettor and at the bottom of the superheater, the temperature of these vessels being thus controlled.

When the fuel has acquired the proper temperature, the air blast is shut off, the stack valve lowered, and the steam is passed upwards or downwards through the fuel in the generator, the resulting hot gas passing down the carburettor. At the top of the carburettor it meets a stream of oil which becomes vaporised and afterwards transformed in the carburettor and superheater into a fixed gas, light hydrocarbon vapours, and a little tar.

The water-gas apparatus has to withstand high temperature, abrasion, slagging action, and spalling. These actions are distributed through the three main vessels, and some of them occur also in the connections. The fireclay linings suffer severely, but owing to extreme and frequent temperature changes it has not been found practicable to substitute silica refractories, and magnesite also proves unsuitable owing to spalling. Recent trials with magnesite blocks enclosed in a thin iron casing seem to have been somewhat more successful. Carborundum materials give a longer life, but are costly.

On construction work better results are generally obtained by using a cement composed mainly of ground material similar in quality to the grog in the brick and a minimum amount of more fusible material. For silica bricks or shapes subject to high expansion, no cementing material is used in many cases, the bricks or shapes being separated by corrugated cardboard of such thickness that at the proper temperature sufficient space is left for the expansion to take place so as to form a tight enough joint.

For control of materials supplied, the tests include those for resistance to deformation under load, for slagging action, fusibility and spalling.

For resistance to deformation under load an automatic device is used for determining expansion at various temperatures under different loads.

"THE BRITON IN FLANDERS."—We have received from Mr. Leopold B. Hill, 2, Langham-place, London, W. 1, a booklet of close upon 100 pages, having the above title, compiled by Mr. E. V. Bisschop, and giving a brief grammar of the Flemish language, words and phrases in Flemish and English, with the Flemish pronunciation. The booklet covers all that is necessary for everyday conversation, and includes also a cycling and a motoring vocabulary. The booklet costs 1*s.* 6*d.* net.

HARBOUR WORKS IMPROVEMENTS.*

(1) WHITBY HARBOUR IMPROVEMENT.

By JAMES MITCHELL, M.Inst.C.E.

THIS paper describes the former rank of the port of Whitby, and the reasons for the loss of that rank. The defects of the harbour, as it was before the carrying out of the new scheme of improvement, are described, the shifting sand bar just outside the entrance, the narrow, and tortuous entrance channel, the lack of deep-water quays, and the great range of sea into the harbour, owing to insufficient shelter. A description of the new works—two new sea piers, a new fish quay with deep water alongside, a new entrance channel, and general deepening of the harbour—follows, and reasons are given for the expectation that Whitby will ultimately become a first-class fishing port.

The harbour lies at the mouth of the River Esk, on the north-east coast of Yorkshire, the position of the river mouth having probably been determined by the crushing of the strata due to a geological fault of over 100 ft. which runs through the middle of the harbour.

The new east and west piers were designed to check the travel of sand from the north-west, and so remove the sand bar at the harbour entrance, while they also serve to reduce the range inside the harbour in stormy weather. To assist the latter object, intercepting jetties have been built out from the old pierheads, and by these means more than 50 per cent. of the breadth of the waves entering between the piers is carried out to sea again through openings left between the old and new piers. The effect of the new piers and wave traps has been most satisfactory, the sand bar having been completely removed, the entrance made safer in stormy weather, and the outer harbour made safe for vessels lying in all weathers.

The piers are monolithic concrete structures, carried to a level of 7½ ft. above h.w.o.s.t., and surmounted by timberwork trestles, on which roadways are carried at a level of 22 ft. above h.w.o.s.t. They are founded throughout on alum shale rock, at depths ranging from 2 ft. to 12 ft. below l.w.o.s.t. The timber trestle-work, as originally designed, was intended to serve as staging, on which would be carried the railways, cranes, &c., required for construction, the lower portion of it being thereafter encased in concrete, so as to form part of the permanent structure. The contractors, however, in view of the exposure of the site, and the difficulty of driving piles in the shale rock so as to withstand the sea, proposed to adopt a novel type of locomotive stages, which would travel on the sea bottom and carry cranes, divers' platforms, &c. This proposal was agreed to, the timber piles being dispensed with, and their place taken by uprights embedded for a length of 7 ft. in the concrete structure. A description of these stages is given, together with their method of operation, and speed of travelling. The difficulties met with in preparing the foundations, the type of concrete casings, and methods of concreting are described. Attention is drawn to various difficulties met with in the diving work, and to the influence of the quality of the concrete in minimising loss of concrete and concrete casing during construction.

The new fish quay is 700 ft. long, the front being curved to a radius of 1,430 ft., and has a depth alongside of 7 ft. at l.w.o.s.t. It is constructed of creosoted pitch-pine, with a close-jointed deck of uncreosoted pitch-pine, and is designed to carry a load of 2½ cwt. per square foot. The method of carrying out the piling work is described, together with the fairing of the curvature of the front of the quay after completion of the piling.

The entrance channel, and the whole of the outer harbour, has been dredged to a depth of 7 ft. below l.w.o.s.t., the channel being extended outwards to a permanent sea depth of this amount. The dredging was greatly hampered by the shallowness of the old harbour.

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(2) THE DESIGN OF HARBOURS AND BREAKWATERS WITH A VIEW TO THE REDUCTION OF WAVE-ACTION WITHIN THEIR AREA.

By RALPH FREDERICK HINDMARSH, M.Inst.C.E.

The author points out the importance of the subject, both in connection with the design of new harbours, and with regard to works of improvement or alteration carried out in existing harbours, and refers to several principles on which the reduction of wave action depends.

He then traces the development of the Tyne Harbour Works, stating some of the reasons which influenced the late Mr. James Walker, Past-President Inst.C.E., in laying down, about 1853, the positions of the Tyne piers as designed by him. The design is commented upon in the light of experience gained.

In its natural state, when beset with reefs and shoals, and with a winding entrance channel, there did not appear to have been much wave disturbance in the harbour.

Complaints were first made when dredging was taken in hand on a large scale, at which time there was still a considerable distance between the pier ends, and as a result of such complaints, Sir John Coode, Past-President Inst.C.E., was consulted in 1884. His opinion was that the changes wrought by dredging, coupled with the action of the piers in confining the scour to the currents, had brought about an entire revolution in the state of affairs, and he recommended:—

1. That the southern wave-trap then in course of construction should be enlarged, and the bed of the trap from low water up to high water formed at an inclination of about 1 in 30.

2. That the position of the timber groyne on the

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* Abstracts of four papers read before the Institution of Civil Engineers, on Tuesday, January 13, 1920.

north side of the harbour, forming the continuation of the stone groyne near Clifford's Fort, should be altered to its present position, and an additional groyne formed to the westward so as to form the present northern wave-trap.

These recommendations were subsequently carried into effect, and the wave-traps and groynes are still substantially in the form suggested by Sir John.

Plans are given showing the harbour entrance in its natural state before the Tyne piers were constructed, and the existing harbour entrance.

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(3) WAVE-ACTION IN HARBOUR AREAS; WITH SPECIAL REFERENCE TO WORKS FOR REDUCING IT AT BLYTH AND WHITBY HARBOURS.

By JOHN WATT SANDEMAN, M.Inst.C.E.

The paper draws attention to the difference between range waves from the sea and short wind waves raised within a harbour. When propagated into a harbour through a deep entrance channel, waves do not break, and their velocity and momentum are only gradually quelled by the reaction of still water within the harbour.

At Blyth, with sea waves at the pier heads of 10 ft. to 12 ft. in height, range waves in mid-harbour vary from 6 in. to 24 in. in height. Such waves move ships alternately ahead and astern, and the momentum imparted to heavy ships when their moorings are slack, has proved sufficient to break steel mooring hawsers. The reduction of range at Blyth has been effected by the construction of intercepting jetties. A new west pier to be constructed will provide similar jetties.

At Whitby harbour range has been reduced by the construction of outer piers which overlap the old pier-heads, the spaces between the new and old piers forming exits for waves intercepted by the old pierheads. The reduction of range is effected both by the breadth of wave cut off, and by its loss of momentum whilst expanding between the new and the old pierheads. The combined effect has been such as completely to tranquillise the harbour, which previously during storms did not admit of ships or boats being moored below Whitby bridge.

The two cases referred to afford examples of methods which it is considered might be more fully employed for the reduction of range without recourse to more elaborate works, where large areas of spending beaches cannot be provided.

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(4) THE IMPROVEMENT TO THE ENTRANCE TO SUNDERLAND HARBOUR, WITH REFERENCE TO THE REDUCTION OF WAVE-ACTION.

By WILLIAM SIMPSON, O.B.E., M.Inst.C.E.

The author briefly describes the practical results of wave-reduction at the two entrances to Sunderland Harbour, devoting particular attention to the north, or River Wear entrance, which is protected by sea piers of recent construction. The general physical conditions at Sunderland are described, including exposure, fetch, and waves. An historical account is given of the early progressive attempts to improve the entrance to the River Wear, culminating, in 1843, in the completion of two sea piers, which proved of great benefit to the port. The construction of these piers, however, was the means of bringing more swell into the harbour, which seriously interfered with the utility of the interior. A bar was also persistently formed at the pierheads, to the inconvenience and danger of shipping. The question of an improved entrance to the River Wear was referred to the Admiralty in 1858, who recommended the construction of sea piers extending into deep water. With this recommendation before them, the River Wear Commissioners (the Port Authority) consulted several eminent engineers, including Sir John Coode, Past-President Inst.C.E., whose scheme of 1876 was adopted, and a commencement made with the works in 1883, under the late Mr. H. H. Wake, M.Inst.C.E. The original width of entrance of 500 ft. proposed by Sir John Coode was increased to 600 ft. by Mr. Wake, and later to 700 ft. by the author. It had been proposed to complete the protecting piers before deepening the entrance channel, to avoid increase of swell into the harbour, but the matter having been referred to the author, he decided, in 1909, to proceed with the deepening and improvement of the channel before completing the south protecting pier. At that time there was a depth of 10 ft. at l.w.o.s.t. in the channel, and the distance between the completed north or Roker pier and the end of the unfinished south pier was 770 ft. In coming to this decision the author had in view the desirability of securing the largest possible entrance to the port, while opportunity afforded, consistent with reasonable protection of the interior from swell, and considered that it would be possible to meet an increase of swell by the provision of an interior expanding area. As a preliminary to the deepening operations, the seaward half of the inner north pier was reconstructed, as the foundations had shown signs of giving way. Deepening operations were commenced in 1909, when a depth of 15 ft. at l.w.o.s.t. was obtained, and, as there was no perceptible increase of swell, these operations were extended until 20 ft. at l.w.o.s.t. had been got. At the same time an inner expanding area was extended and deepened. A large part of this work consisted in the removal of limestone rock, which was either carried out by the rock dredger Wear without either blasting, or broken up by mechanical means.

No increase of swell at the harbour having resulted from these operations, the author recommended the completion of the south protecting pier by adding a head only, so as to leave an entrance of 700 ft., and this work is now in hand. As a result of the construction of the protecting piers, and the deepening of the entrance channel, the bar, which had so long encumbered the port, has disappeared. The action of swell in the exterior expanding area is described. The action of swell in the interior area is shown to be largely due to the shallow depths alongside the old river piers, which tend to lead it into the harbour. The general conclusions which the author draws, in regard to the River Wear entrance, are that the proportions of expanding area to entrance and disposition of wave basins of the exterior are generally satisfactory, the factor of wave-reduction by these agencies being about 65 per cent. For the inner expanding area the results are good, as traffic is not interfered with during storms. The total value of the wave-reducing agencies, both exterior and interior, is about 90 per cent.

With regard to the south entrance, the author explains its general configuration and design, and shows that the results are not satisfactory, as the expanding area is too small and shallow, the factor of wave-reduction being only about 40 per cent.

The author, finally, sums up the relative merits and values of the wave-reducing agencies at both the north and south entrances at Sunderland.

CATALOGUES.

Vacuum Cleaner.—An electrically-driven machine for cleaning carpets, &c., is described in a catalogue received from the Sun Electrical Company, Limited, 120, Charing Cross-road, London, W.C. 2. The machine has a revolving brush in the nozzle.

Brake Solenoids.—Four standard sizes of brake solenoids for alternating-current circuits are described in a catalogue from the Metropolitan Vickers Electrical Company, Limited, of Manchester. These are totally enclosed, and weatherproof, and they can pull up to 150 lb. through a stroke of 2 in.

Engineering Works.—Messrs. William Beardmore and Co., Limited, of Glasgow, have reprinted, in handsomely illustrated form, a description of their various works which appeared in the journal *Empire Illustrated*. As the description includes steel-making, forging, ship-building, locomotive and aircraft construction, it makes very interesting reading.

Electric Power.—The General Electric Company, Limited, 67, Queen Victoria-street, London, E.C. 4, has issued catalogues describing (*a*) an extension of the Poplar Borough Council Power House, including a 4,750 k.v.a. turbo-alternator and two 1,000 kw. rotary converters made by the company; and (*b*) an engineering works' power and light equipment comprising generating machinery and about 80 motors ranging from 100 h.p. to ½ h.p.

Electric Furnaces.—Muffle furnaces of square, circular and D section are described and illustrated in a catalogue issued by Automatic and Electric Furnaces, Limited, 281, Gray's Inn-road, London, W.C. 1. Small sizes for laboratory use are included. The cost of current in pence per hour at 1*d.* per unit, is given for each size, so that the actual cost of working can be easily calculated when the local rate is known. An oven furnace suitable for annealing optical glass is also shown.

Steam Shovels.—A number of catalogues issued by the Ball Engine Company, Erie, Pa., U.S.A., show several steam driven shovels actuated by a jib crane mounted on a turntable and carried on roadway or railway wheels. Generally a box scoop with digging prongs working with an upward and forward sweep is employed, but the machines may be used with a drag bucket, which is thrown out and drawn back, and also with a grab bucket. Messrs. Gaston, Limited, 20 Bishopsgate, E.C. 2, are the importers of the machine.

Small Engines.—A series of vertical engines, from 1½ h.p. to 15 h.p., running on petrol and light oil, are described in catalogues issued by the makers, the Novo Engine Company, Lansing, Michigan, U.S.A. The engines are well enclosed for rough and outdoor use by building or road-making contractors, and are quite self-contained with a fuel chamber in the base and a cooling water hood. They are supplied separately or with hoisting, pumping or other machinery attached. The importers are Messrs. Gaston, Limited, 20, Bishopsgate, E.C.2.

Oil Engines.—An exceedingly well-produced catalogue, in French, from the Soc. Anon. Augustin Normand, Havre, France, contains many exceptionally fine reproductions of photographs of their heavy oil engines for marine and land use, with descriptive text, and also gives an excellent series of line engravings of ships engined by the company. An historical note of more than usual interest shows that this firm built their first sailing ship in 1628, their first steamship in 1829, the first triple-expansion engine in 1871, and their first submarine in 1917.

Electric Welding.—Three catalogues from the Alloy Welding Processes, Limited, of 14, Cockspur-street, London, S.W. 1, contain particulars and explanatory information about stationary and portable arc welding plants; and standard electrodes for arc welding, as well as a list of welding materials such as rods for the oxy-acetylene process and electrodes for the arc process. These materials include a considerable range of cast-iron, mild steel, nickel steel, carbon steel, high-speed steel and manganese steel, which give some idea of the efforts now being made to provide for each special kind of work.

Motor-Car Engines.—Messrs. W. H. Dorman and Co., Limited, of Stafford, have taken up the manufacture of motor-car engines on a very large scale, in forms suitable for many types of cars. They have standardised 10 sizes, ranging from 10 brake horse-power to 72 brake horse-power, all of which run at 1,000 r.p.m. The engines may be used to replace old engines when a car is being overhauled. A general description of the engines, in popular form, is given in an 80-page booklet written by Mr. M. W. Bourdon, and very fully illustrated. Another booklet gives a long series of extracts from the daily and motor-car journals. Both publications are entitled "The Heart of the Car is the Engine."

Lubricators.—A forced-feed lubricator, made in a large range of sizes and adapted for all kinds of engines, compressors, cranes, &c., is described in a catalogue received from the McCord Manufacturing Company, of Detroit, U.S.A. The lubricator consists of a cast-iron tank into which one or more (up to 25) pumping units are inserted through the cover. The driving shaft is inside. Each unit may be separately regulated while in place, and each may be removed for inspection. The pump is of the two-stage plunger type. One plunger takes a quantity of oil from the tank to a compartment, where it passes a sight-feed glass, and it is then delivered to the bearing or other part to be lubricated by means of a second plunger.

Steam Superheater.—The advantages o superheating steam are very clearly explained in a catalogue issued by the North-Eastern Marine Engineering Company, Limited, of Wallsend-on-Tyne. The superheater made by this company is especially suitable for application to Scotch marine boilers, the type of boiler almost universally used in merchant ships. The steam is led from the boiler stop valve through a pipe which passes successively into four of the boiler tubes and thence to the engines. The doubling over of the heating tube inside the boiler tube is necessarily sharp and is provided for by a U-piece, made separately, and suitably thickened to withstand the hot blast on the curved end. A number of these pipes connected to headers for the wet and superheated steam constitute the superheater. The catalogue points out that the advantages of the superheater are only to be obtained by giving the best attention to the engines, boilers, piping and feed water. The saving in fuel, allowing for the superheating fuel, is estimated at from 13 per cent. to 17 per cent. with triple expansion engines, and from 9 per cent. to 12 per cent. with turbines.

Pneumatic Pickaxe.—To provide the coal-miner with a power-driven pickaxe is by no means an easy task, and it is certainly not simplified by the fact that the miner is not always anxious to avail himself of its help. The conditions of working in a mine are such that it is impossible to expect what would be considered "fair-play" for such a tool under almost any other conditions. Some of the earlier inventions failed because the movement of the point of application, which is different from that of the riveting hammer, led to breakage of the recoil spring or the sleeve, or even of the hammer itself. Messrs. Hugh Wood and Co., Limited, of Newcastle-on-Tyne, have produced a pneumatic pickaxe which works with an air pressure of 60 lb. to 80 lb. per square inch. Its action automatically ceases when the resistance of the work is removed, and it can be dismantled and re-assembled without tools other than a tommy and spanner. The fact that it is unnecessary to observe any marks in this operation is an important desideratum, as tools of this class used in a coal mine should be taken to pieces, washed and lubricated daily. The tool weighs only 18 lb., is under 16 in. long, and has a piston stroke of 5½ in. All the parts are finely made to standard size, and are interchangeable.

VISIBILITY METER.—The visibility of distant objects is impaired and influenced by any turbidity of the atmosphere caused by the presence in the air of dust or gases affecting the light absorption and dispersion, by heat giving rise to density fluctuations, by wind and moisture, and by the illumination and its direction, and it depends, further, upon the physiological condition of the eye. For the latter reason direct eye estimates have little value. The visibility meter (Sichtmesser) which Professor A. Wigand, of Halle, last year described in the *Physikalische Zeitschrift* (1919, pages 150 to 160), resembles in its general shape, a hand-s ereoscope. In front of the eyepiece is mounted a wooden disc in which sight windows are arranged in a circle; the windows are fitted with screens or filters of ground glass, numbered respectively 0, 2, 4, 6, 8, 10, 12, 14; there is a second disc which has only one window, marked 1. The observer looks at some distant object, his target, which may be a house, a tree or a steeple, and turns the discs about their common axis until the target disappears. If that has been attained by using the screens 6 and 1, the opacity is 7. The unit screen is so ground or sand-blasted that it has about 10^6 grains per square centimetre; on the other screens the numbers of the grains are higher or the screens are more opaque. When observations are to be made high up in the air, a balloon serves as target, while for observations from a balloon, a dark cloth is spread on the ground. With the instrument is supplied a scale diagram consisting of three lines joined so as to make up an inverted N. On the left vertical limb are marked the distances in kilometres, on the diagonal limb the numbers of the filters, on the right limb the visibilities. The mean opacity of the instrument has been found to be 14·3 on days of maximum visibility, and the visibility of an object of opacity σ at a distance l is given by visibility $s = l/(14 \cdot 3 - \sigma)$. Supposing the target at a distance of 10 km. disappears when the filter 6 is put in front of the apparatus; then a line drawn through the points 10 and 6 (or a rule applied to these points on the scale) will cut the right limb in the point 3, giving a relative visibility of 3. The visibility unit adopted is that of the Prussian meterological service. There are really three scales to the instrument, for maximum distances of 0·1 km., 11 km., and 110 km. respectively. The instrument should not be used in direct sunlight.

THE EFFECTS OF EDUCATIONAL EFFORT UPON INDUSTRIAL EFFICIENCY.*

By Mr. F. W. GILBERTSON.

I THINK I can best use the time allotted to me by making a general statement from the point of view of a business man and an employer of labour, and by referring no more than is necessary to the machinery of education with which I am not sufficiently acquainted, and with which there are others qualified to deal. The views I express are individual, but I believe they are those of a large number, and an increasing number, of the class engaged in the direction of industry.

I start with the assumption that as this country can only support its population by purchasing from abroad many of the necessaries of life, and can only pay for these by the fruits of its industry, it is not possible to consider the development of education and not to regard the interests of industry and the effects of all educational effort upon industrial efficiency as of paramount importance. I hope this view will not be found really to entail a narrow outlook, but it is a good reason for inviting the interest and help of all sections of the people who are engaged in industry. So far as education may be regarded as a training for an industrial or commercial career, it is desirable to have some picture of the requirements of industry before us and for the purpose of illustration I use the example of the works with which I am connected—in which four kinds of manufacture are carried on, and which are fairly representative of the metal and many other industries other than engineering, although, of course, the facts are applicable only to a limited part of the whole life of the nation. I would, roughly, classify the 2,000 persons employed in these particular works, as follows :—

Section 1.—(*a*) Those engaged in the central control with wide financial and commercial experience, and some general technical knowledge, numbering eight. (*b*) Departmental managers and foremen having charge of the manufacturing operations, numbering nine. (*c*) Trained technical men, such as the elder chemists, metallurgists, chief engineer and electrician, numbering 12. (*d*) Clerical staff in the office and in the works, other than those already noted, numbering 80. (*e*) Working engineers, fitters, millwrights, electricians, including engine drivers, numbering 112. (*f*) Foremen not included in (*b*), numbering 9. (*g*) Skilled workmen whose efficiency may be directly increased by some knowledge of the science of the processes in which they are engaged, numbering 165.

Section 2.—(*a*) Other skilled and semi-skilled men, whose skill is mainly manual, numbering about 1,050. (*b*) Unskilled labourers, 342. (*c*) Boys and female labour, 220.

The first observation I would make on these figures is to call attention to the large number of quite unskilled labourers employed, although the proportion has tended to decrease with the extended use of machinery. I would then refer to the relatively small number of persons included in Section 1, in the value of whose work one would expect a better intellectual equipment to be directly reflected, and finally to the still smaller number of posts that really call for special training. If better education of the mass was thought likely to improve the quality of manual work, without doubt the experience of recent years is disappointing. A young generation of workmen has grown up comparatively quite well educated for the most part and highly intelligent, but regarded purely as workmen their skill and their power of turning accumulated observation into good work are no greater than their fathers' : the explanation probably is that they have so much more in life to interest them that their work does not command the same degree of concentrated attention, and their energies are diffused, even if as must often be the case, the wider outlook open to them has not made manual work, with its dull repetition, actually distasteful. I am not sure, if we consider the bracing effect of struggling against difficulties, whether we could expect the opening of an easier road to produce the masters of craft whose marvellous skill we admire in past examples of architecture, art, and industry achieved with inferior tools.

In office work, I am unable to trace any connection between improved facilities for specialised training and higher commercial efficiency. The best clerk is he who is capable of performing accurately the largest amount of work in the working hours, and is usually one who has worked his way up from the bottom, mastering the duties of each grade as he passed through it—as, excepting the limited number of persons who decide policy, it is not breadth of vision, but thorough work in a narrow groove that makes for efficient administration.

It might be expected that in the class that includes engineers, joiners, millwrights, electricians and mechanics generally some early specialised training would be of value, but experience does not seem to fulfil such expectation. Hitherto, the best men have been those in whom works experience has developed an aptitude for such branches of work, and who have then, long after school age, taken advantage of any opportunity of acquiring theoretical knowledge in complement to their practical knowledge of their special subject. In the higher branches of engineering, and in the case of men who intend qualifying themselves ultimately to fill posts of chief engineer in large works, academic training is of the greatest value if it be gained in a district and under a system that permits experience of practical work and works' practice to alternate with school work, and these conditions do not exist in Wales.

The men known as furnacemen in most of the metal industries are men who are engaged in the mechanical work of charging and tapping furnaces, but they are also controlling most delicate and complex chemical reactions, under some technical direction, but mainly by rule of thumb, or by treating any set of conditions they are able to observe in the traditional manner, or in the manner they were at some previous time instructed to do. These men are very highly paid, and there is an immense field open for improved results, if the chemical side of the work could be separated from the mechanical side, or if the workers were scientifically trained men, as, to a large extent, is the case abroad. It is obvious that a very thorough and prolonged academic training is needed for chemists and metallurgists, but with the exception of these and perhaps of the furnacemen, if the status of the latter could by agreement with the trade unions be changed, I think it is necessary to modify the views we commonly held, and to accept the conclusion that early specialisation is of no value to those who are going to enter industry.

In the case of working men generally it would seem that the natural sorting-out that occurs in practice, by which one boy takes to mill work, another to the tin-house and another to the carpenter's shop or fitting shop, and by which some develop capacity and ambition beyond their fellows and increase their powers by evening study—study that is of the highest value, because it is voluntarily undertaken for a purpose, and means something real to the student in terms of his daily experience—is a very practical method of making the best of each individual provided the ground work has been sufficiently good for all. It follows, that from this point of view whole-time general education to 16 years of age, with every subsequent opportunity for attending voluntary continuation and particularly voluntary technical classes, is the best suited for our industrial population, but it is impossible to lay too much stress upon the need for the fullest provision of such voluntary opportunities.

In a village, in which one works is situated, it may be desirable to provide teaching in just as many separate subjects as in a densely-populated area. If every one is to have the opportunity of making the best of his life a class may be needed in such subjects as mining, metallurgy, engineering, chemistry, mechanical drawing, and so on in every district in which some working men find their fullest development is hampered by want of knowledge of their subject. Where public money cannot properly be spent on the provision of classes under strength the co-operation of employers is called for, and I think machinery should be devised whereby the employers' organisations can be offered on definite terms, the provision of a technical class in cases where the minimum grant-earning attendance is not forthcoming. In suitable cases employers can and do provide their own classes, and this method is capable of much expansion.

I do not think it is possible to improve the machinery of education in Wales in the interests of those who desire and are worthy of higher education. There is room for co-operation between all classes of thoughtful people, education authorities, and employers' and workmen's organisations particularly, in the direction of stimulating the enthusiasm of parents, and where parents fail, of smoothing the way for individuals of promise and of late development, and generally of greasing the wheels; but the ladder is there for all to climb who will—opportunity is equal and the steps are easy.

I think, however, as time goes on and as, perhaps, the organisation and methods of our manufacturers become more complex, some serious consideration must be given to the problem of placing university men in industry, so that they will receive compensation for and not be prejudiced by the sacrifice they have made, and the attainments they have reached. This subject will become of immediate importance when the School of Metallurgy is established at Swansea University College.

I have been unduly long in reaching my first conclusion, and will endeavour to cut short the considerations that lead to my second and more important one. An industrial community requires its skilled workmen, its commercial men, clerks and chemists, and so on, but their activities are of low value without the will to work—to work well and to work hard. Nature supplies the will to work, but her methods are crude and often cruel. To illustrate my meaning, in the savage state natives are taught to work well and hard by first creating tastes that can be gratified only in proportion to the work performed and the wages earned. In the stage of economic development typified by the history of the nineteenth century the rewards of manual, as of all other work have, as a matter of course, been proportionate to the value of the work performed, and the will to work has often been stimulated or restored by the severity of the economic punishment that has followed slackening effort. Nature, in fact, provides that a proper standard of work shall be maintained in quantity and quality by exercising influence at either end, on the principle of the carrot or the whip.

During recent years the healthy pleasures of life available to almost all classes have enormously increased, without inducing an increased love of work as the reward of which they may be enjoyed, but rather we are faced to an unexampled extent by a world-wide desire of all classes to obtain greater pleasure in life with the expenditure of less work. We may, therefore, expect Nature to act shortly at the other end, and to compel harder work in return, not now for the pleasures but for the necessaries of life, unless the harsh operation of her laws can be avoided to some degree at least by substituting the exercise of reason for economic force. The purely material interests of industry may therefore very well be involved in the real education of as large a number of all classes of the population as possible, in broadening their outlook and in increasing their powers of comprehension, so that work and hard intelligent work shall be generally understood to be not the alternative to pleasure, but the only means with which the true pleasures of life can be purchased and enjoyed.

From quite another point of view the need of a true and broad training of the young is urgent. We observe the industrial population split into two forces, the relations between them being in the course of profound modification. We are also witnessing the rapid cohering of those who work with their hands into a political block animated by a single policy, and therefore not unlikely before long to be entrusted with the responsibility of the government of the country. Those who work with their hands must as yet be the least educated, but they will always form the most numerous class, and will certainly be responsible for many experiments, many changes, and probably many mistakes as they learn to use the new powers that are unquestionably theirs. It is obviously, therefore, to the interest of the country that its future citizens should be as well prepared to take their part as education can make them, and that the power of forming sensible balanced opinions, of sifting evidence, of realising the limitations of the individuals' knowledge, and the creation of a body of citizens capable of producing a sound healthy public spirit are far more important aims than the achievement of pure technical efficiency.

I do not think any honest observer would deny that the public schools of this country have succeeded in producing a saner and more dutiful public spirit than any other agency in history, and it is worth while seeking the causes and utilising as many as possible in our education system for the masses of young people. There are two main grounds for encouragement in the opportunity Mr. Fisher has given us for introducing school games as part of education, and the development of boys' we fare work in factories with evening and games clubs in which the boys are led themselves to organise the necessary discipline. As the majority of boys will not be able to proceed to the university, it is encouraging to observe that the type I refer to has been produced by the public school, and that the character formed in boys of 17 to 19 years old has stood the test—experience would almost suggest that the university, where it has modified the character of these boys at all, has as often narrowed their outlook as enlarged it. Amidst all the countless kinds of mental activities and specialisation required to make up a progressive State I strongly urge the need of a solid background, of the existence of an overwhelming body of persons possessed of the attributes of the English gentleman, using the word in its true meaning, which we know by experience is applicable to representatives of all classes, whatever the circumstances of their birth and opportunity.

These considerations lead us to recognise the vast importance of the quality and outlook of our teachers. The best results are unattainable unless we have the services of a body of persons properly trained, with broad vision and possessed of the highest traditions of Civil Service. I have endeavoured in a most imperfect manner to suggest that even from the point of view of an employer our proper aim should not be to produce special types, but citizens fit to think for themselves and able to grasp means abundantly provided for developing themselves their own particular gifts as life unfolds the desire and the opportunity. Even an employer can realise that the true interest of the State lies in providing the means of sympathetically leading out of the child whatever natural and inherent power he may possess, and of wisely developing it so that the process of education does not end with school, but shall be carried on through life with the true happiness of each individual as the goal; but an employer is particularly well able to know that full development occurs at very different ages with different persons, and that the examination test does not place men in the order of their final life achievement. I close with a few thoughts upon the special responsibilities and opportunities of employers.

1. The routine of placing and promotion should be seriously explored in order to see whether better encouragement cannot be given to parents and boys to take the fullest advantage of all facilities for better or special education.

2. Employers should be urged to find room at proper rates of remuneration for university graduates who desire to enter industry, and, to assist them, to give facilities to students to gain practical acquaintance with industrial life and processes during vacations.

3. Employers should be ready to assist either individually or collectively, young men who have slipped through the mesh at school, and have shown gifts worthy of development after they have entered industrial life.

4. Employers should, I am inclined to think, encourage intercourse between their technical staffs and the teachers of their district, throw their works open to the latter with or without their pupils, and use any opportunity that offers itself of adding to the experience and enlisting the co-operation of a body of intelligent men actuated generally by the desire to perform their duty well, but thrown perforce into a somewhat narrowing groove.

5. The real control of industry is so absorbing an occupation that those actively engaged in it can be of little service on education authorities, and those who have time to give to such work cannot in the fullest active sense be regarded as representative of industry and all its problems, and yet close contact is called for. It is hoped the experiment initiated by the manufacturers of South Wales will succeed and be copied.

The object of appointing an official themselves is to stimulate co-operation, to keep each side acquainted with the wishes and difficulties of the other. It is also to be expected that the start and growth of university education at Swansea will afford the manufacturers and business men of this district the opportunity that is needed to take a deeper and ever-growing interest in the work of education; I believe they welcome it, and will fix a high standard as the goal of the common effort.

* Paper read before the Educational Board of South Wales Manufacturers, at Cardiff, January 9, 1920.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

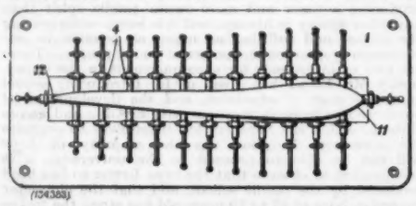
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

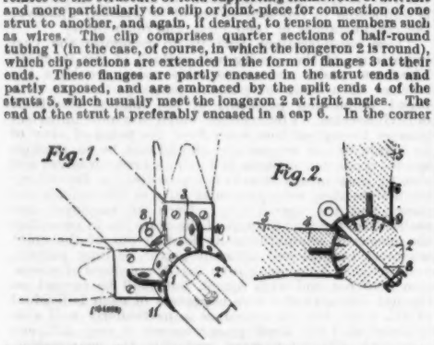
AERONAUTICS.

134,383. G. Jordan, Rugby. Rib Profile Setting Table. (5 *Figs.*) November 27, 1918.—According to the present invention, apparatus for setting the profile of and making aeroplane ribs and the like comprises the combination with a table 1, of a pair of springs 11, disposed on edge on the surface of the table a distance apart, each spring being carried on a plurality of blocks 4 arranged at different points of its length, and means for



adjusting the position of the blocks to cause the springs to take up any desired shape. An adjustable block 12 is also arranged at each end of the table, the face thereof being recessed to accommodate the ends of the springs 11. Preferably the table is constructed so that the centre portion is removable for the purpose of allowing the required profile or shape to be drawn thereon. (*Sealed.*)

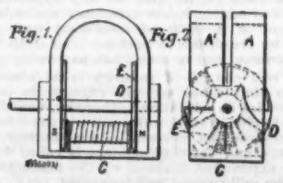
134,858. F. Handley-Page, London. Aircraft Frame Structures. (2 *Figs.*) March 15, 1918.—The present invention relates to the structure or load supporting framework of aircraft and more particularly to a clip or joint-piece for connection of one strut to another, and again, if desired, to tension members such as wires. The clip comprises quarter sections of half-round tubing 1 (in the case, of course, in which the longeron 2 is round), which clip sections are extended in the form of flanges 3 at their ends. These flanges are partly encased in the strut ends and partly exposed, and are embraced by the split ends 4 of the struts 5, which usually meet the longeron 2 at right angles. The end of the strut is preferably encased in a cap 6. In the corner



between two adjacent struts a wedge-shaped piece may be inserted which has purpose firstly of receiving an eyebolt 8 for a diagonal tension wire, and secondly to prevent the spreading of the split ends 4 of the two adjacent capped struts 5. In the case where the struts 5 are arranged only at less than four opposing points, each of the clip parts then may be turned up as at 9 to prevent the spreading of the outer half of the said split caps. The portion 3 of the clips may be pierced at their ends (as at 10) to receive bracing wires or like tension members, and will be perforated at their centres to receive eyebolt 8. The clips may further be secured to the longeron by screws 11 or the like. (*Accepted November* 26, 1919.)

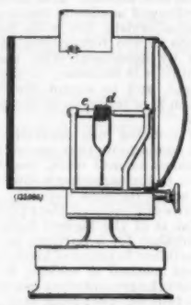
ELECTRICAL APPARATUS.

135,073. V. Crabb, Wimbledon Common. Dynamo-Electric Generators. (4 *Figs.*) February 14, 1919.—This invention relates to dynamo-electric generators which, although primarily designed for supplying energy to electric ignition devices such as may be used for internal-combustion engines, in which case a permanent magnet field would usually be employed, can also be applied to the generation of electric energy for other purposes, such as the supply of electric lighting and power circuits. The essentially novel feature of the invention is the special arrangement of the parts which constitute the magnetic



circuit of the generator and comprise two stationary field magnet A, A1, or sets of field magnets, so arranged that adjacent pole pieces are of opposite polarity, a stationary armature or core C of magnetic material encircled by a coil or coils and separated by an air space at either end from the pole pieces of the field magnets, and a rotating element D comprising iron or steel segments E, each of which in rotation alternately closes the magnetic circuit of the two field magnets through the armature core. The particular disposition of the magnet poles, armature core and magnetic segments is such that each segment in turn produces a magnetic flux through the core first in one direction and then, after a sudden reversal, in the opposite direction as it passes from the field of one magnet system to that of the other magnet system. (*Accepted November* 26, 1919.)

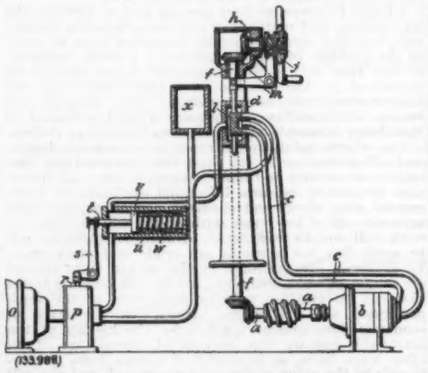
135,066. H. B. Grylls, Weybridge, and W. Heape, London. Electric Arc Lamps. (5 *Figs.*) February 10, 1919.—This invention relates to electric arc lamps such as are employed in connection with searchlights and of the kind in which means are provided for cooling the positive carbon. The invention consists in an electric arc lamp of the kind referred to in which there is provided a member *d* arranged around, or in proximity to, the positive carbon *c*, and projecting somewhat in order to enclose or screen part of the space occupied by the arc



through which member water or other cooling medium is passed, the arrangement being such that the flame of the arc is either entirely eliminated or reduced to a minimum. In carrying this invention into effect in one convenient manner, as in its application to a searchlight, the improved searchlight is formed in any desired manner or in accordance with general practice. The member *d* is a coil conveniently of copper or formed from any other suitable material, having a water current passed therethrough either continuously or intermittently, so that it may be efficiently cooled. (*Accepted November* 26, 1919.)

HYDRAULIC MACHINERY.

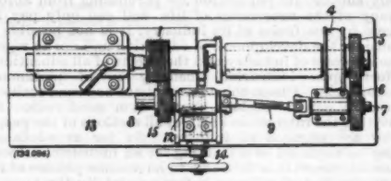
133,988. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne, F. L. Robertson, Newcastle-on-Tyne, H. W. Lee, Newcastle-on-Tyne, and F. P. Fee, Newcastle-on-Tyne. Controlling Power Operating Mechanism. (1 *Fig.*) September 20, 1918.—This invention relates to improved means for controlling the supply of liquid under pressure to mechanism operated thereby. According to the invention, the control valve of an engine is opened by the first movement of a hand wheel, continued movement of the hand wheel keeps the valve open, and on cessation of such movement the valve is actuated to cut off the supply of liquid while, if the power fail, the continued movement of the hand wheel rotates the shaft. *a* is a worm shaft which can be actuated by an engine *b* to which liquid under pressure is supplied by pipes *c* leading from a valve casing *d*. The shaft *a* is geared by bevel gear, a spindle *f*, and bevel gear to a spindle *h*, on which is a quick-thread meshing with a similar thread cut in the interior of the boss of a hand wheel *j*. Collars limit the movement of the hand wheel along the spindle. A control valve *l* in the casing *d* is actuated by a bell crank *m* on which is a roller working in a groove cut around the boss of the wheel *j*. *o* is an electric motor driving a pump *p*, the amount of liquid delivered by which can be varied in well-known manner by the movement of a rod *r* connected by a lever *s* to the piston rod *t* of an accumulator *u*, the rear of piston *v* being loaded by means of a spring *w*, which tends to keep the amount of liquid delivered by the pump at a maximum.



When the electric motor is started, liquid is pumped from a tank *x* to the accumulator *u*; this forces in the piston *v* and centres the pump, the liquid being then stored in the accumulator at a pressure determined by the strength of the spring. The first movement of the wheel *j* moves the valve *l*, admitting liquid from the accumulator to the engine *b*, turning the shaft *a*. This supply of pressure from the accumulator causes its piston to be moved forward therein by the spring and fixes the amount of liquid delivered by the pump so as to supply just the amount of liquid required for the necessary speed of revolution of the shaft *a* which speed is determined by the rate at which the hand wheel *j* is turned. If the wheel continues to be turned, its movement assists through spindle *f* the power of the engine. On the hand wheel being held from rotating the motion of the spindle *h* is continued until the hand wheel is thereby moved to the centre of its axial travel, thereby closing the valve and causing the engine *b* to come to rest. The pump continues to deliver liquid until such a time as the pressure in the accumulator is sufficient to force the piston *v* back and restore the condition in which the delivery of the pump is a minimum. Should it be required to turn the shaft *a* for some time the hand wheel may be released while the valve is open and the motion will continue until the hand wheel, the motion of which will continue under these conditions is stopped. Should the power fail, the shaft *a* may be turned by turning the hand wheel. (*Accepted November* 5, 1919.)

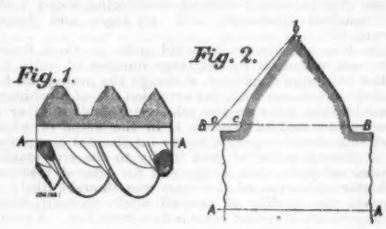
MACHINE AND OTHER TOOLS, SHAFTING, &c.

134,086. T. Browett, Hampstead. Grinding and Finishing Screw Threads. (5 *Figs.*) November 26, 1918.—The grinding and finishing of a screw thread is effected by a lap or hob which is provided with a screw thread and is rotated in contact with the screw thread of the gauge or other part, and the invention is characterised by the fact that the lap or hob and the gauge or other part are at the same time subjected to continuous endwise relative movement. 1 is the screw to be ground supported on centres and driven by a carrier in known manner by means of the pulley 4. The shaft carrying the pulley 4 has at the end a spur wheel 5, which meshes with a second spur wheel 6 mounted on a shaft 7 which drives a spindle 8 through a telescopic spindle 9 and universal coupings. The spindle 8 is arranged exactly parallel with the screw 1, and is carried in a bearing 12 mounted to slide transversely on the bed 13, and is adjustable in position



by means of the handwheel 14. The bearing 12 may be mounted to slide longitudinally of the bed 13. A lap 15 having a thread of opposite hand to the thread of the screw 1 is mounted on the spindle 8 by means of a feather, so as to be slidable longitudinally thereon. In operation, the screw 1 is rotated by means of the pulley 4, and the lap 15 is driven in an opposite direction through the spur wheels 5 and 6, the shaft 9 and the spindle 8. The lap 15 and the screw 1 being in contact, the thread of the screw is ground and the lap 15 moves evenly and continuously from end to end of the screw 1. The direction of the drive is then reversed, whereby the lap travels in the opposite direction. This action tends to correct any error in pitch or form and avoid one part being ground more or less than other parts of the thread. The axial travel of the lap is limited so as to prevent it entirely running out of engagement with the screw 1. (*Sealed.*)

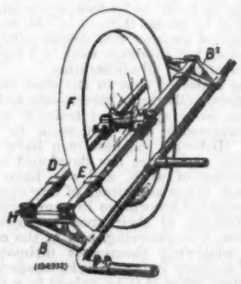
134,186. P. Brown, Lockwood, Huddersfield, and F. J. Bostock, Lockwood, Huddersfield. Worm Gearing. (2 *Figs.*) August 28, 1919.—This invention comprises an improved construction or formation of the thread of the worm. In the improved construction or shape of thread embodying this invention, the sides of the thread are so formed that the motion from the worm or the wheel is mainly that of a rolling action whereby a worm is obtained capable of giving increased efficiency. A, A, represent the axis of the worm and B, B, the root or bottom diameter of the thread. Although not necessary for the invention, B, B, can suitably be made the axis of the hyperbola, the vertex of which is at the point *a*. The formation



of the hyperbola which constitutes either side of the thread is controlled or determined by its asymtote *o*, *b*, which intersects the line B, B, at the point *o*, situated at a suitable distance from the point *c*. The angle which the asymtote makes to the axis B, B, is preferably made approximately equal to the angle that the worm thread on the cylinder of the root diameter makes with the worm axis. The thread of the worm can be cut in any of the ordinary machines now employed in the cutting of worms, or it can be cut in the lathe by employing a tool whose shape is identical to the required hyperbolic curve, and the worm wheel can also be cut in the usual way by means of a hob made to correspond with the worm. (*Accepted November* 5, 1919.)

MOTOR ROAD VEHICLES.

134,932. A. R. Grindlay, Coventry, and Grindlay (Coventry), Limited, Coventry. Sidecars. (1 *Fig.*) November 14, 1918.—According to this invention, a spring suspension for a side car comprises the combination with a pair of brackets B, B2, projecting from the frame, the one in front of and the other behind the wheel F, of a pair of leaf springs D, E, one on each side of the wheel, which carry the wheel spindle



and are attached to the brackets. The drawing is a perspective view of part of a sidecar chassis showing the application of the invention. The laterally-projecting brackets B, B2, lie substantially parallel with the wheel axle, one in front of, and the other to the rear of the outer edge of the wheel periphery. The springs are directly pivoted to the front bracket B2 and connected with the rear bracket B by shackles H. (*Accepted November* 26, 1919.